N-63-4-2

BOEING

SEATTLE, WASHINGTON

THE BOEING COMPANY

NUMBER D2-80086

UNCLASSIFIED TITLE LANDING GEAR DEVELOPMENT

MODEL NO. X-20A CONTRACT NO. AF33(657)-7132

ISSUE NO. 10 ISSUED TO Armed Services Technical Info.

CLASSIFIED TITLE
(STATE CLASSIFICATION)

See Sub-Sections
CHARGE NUMBER

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RELIABILITY APPROVAL			
		(DATE)	

VOL. NO.
SEC. PAGE 1 OF 4

2-5142

DOCUMENT, TITLE PAGE U3 4237 9000 REV. 1/61

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CONTRACT REQUIREMENT

This document is submitted in partial fulfillment of paragraph B(1.1.1.1.9.2) of the Statement of Work, System 620A, Exhibit 620A-62-2, dated 26 January 1962, revised 1 August 1962.

SUMMARY

A screening test program was conducted on five (5) promising materials for use in the X-20 landing gear energy-absorbing system. The materials tested were Inconel, "A" Nickel, Hastelloy X, 19-9DL, and 304 ELC. A total of two hundred and two (202) two-inch gage length tensile specimens were tested under various combinations of temperatures and strain rates to obtain stress-strain curves for comparing the materials. Approximately three-fourths of the specimens tested were Inconel and "A" Nickel, the two most prospective materials based on preliminary evaluation. Inconel was concluded to be the over-all best energy strap material for the X-20 landing gear application.

The energy strap development program was continued with the testing of proposed full-scale main gear and nose gear energy strap configurations under simulated X-20 landing environments. Ten (10) main gear and twelve (12) nose gear Inconel energy strap specimens were impact tested using a drop test rig to obtain load deflection curves. Incremental lengths and diameters were measured before and after impact test to determine uniformity of strain along the length of the strap. Several strap specimens were loaded to failure following the impact tests to establish maximum energy-absorbing capacities.

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INTRODUCTION

This report is the result of work accomplished on EWAs 5-637, 5-638, and 5-639. This work was performed in order to obtain empirical data for determining the optimum X-20 landing gear energy strap material and the energy-absorbing characteristics of the proposed full-scale main gear and nose gear energy strap configurations. Using a metal strap deforming in the plastic range as a means for absorbing landing impact energy requires a material and configuration which displays a large uniform strain and yields efficient landing gear load-stroke curves over the applicable range of X-20 landing temperatures and dynamic loading rates. Under simulated landing environments, stress-strain curves were obtained and used as a means for comparing several promising energy strap materials, and load deflection curves were obtained for the full-scale straps for determining energy-absorbing characteristics.

THE BOEING COMPANY

NUMBER D2-80086 MODEL NO. Dyna-Soar

TITLE LANDING GEAR DEVELOPMENT

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RELIABILITY APPROVAL		5-14-63 (DATE)

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AF33(657)-7132
CONTRACT NO.

5-76200-5580-05637-1-2-5353
CHARGE NUMBER

SECTION TITLE PAGE U3 428 0000 REV. 2/61

2-5142

1.1 SUMMARY

1.1.1 An evaluation program was conducted to determine the energy absorbing characteristics of five (5) promising energy strap materials for use in the X-20 landing gear energy absorbing system. The materials tested were Inconel, "A" Nickel, Hastelloy X, 19-9DL and 304 ELC. Seventy-three (73) tensile specimens were tested in the preliminary phase of this program. The specimens were tested at temperatures of 70°F, 600°F and 800°F and at 0.005, 200 and 300 in./in./min. average strain rates. These temperature and strain rates simulated the landing gear operational environments.

1.1.2 Comparison studies of the preliminary test results indicated Inconel as being the overall best energy strap material prospect with "A" Nickel and Hastelloy X next, both having approximately equal desirable characteristics. Therefore, "A" Nickel and Hastelloy X materials were selected along with Inconel for further testing.

1.1.3 Seventeen (17) "A" Nickel and Hastelloy X specimens were tested at -65°F at average strain rates of .005, 200 and 300 in./in./min. to determine which of the two materials will be carried through the complete final screening phase of the program along with Inconel. The test results indicated "A" Nickel as being the more prospective of the two materials.

1.1.4 Final screening of Inconel and "A" Nickel included tests of sixty (60) tensile specimens of each of the two materials. These tests were conducted at average strain rates of 0.005, 50, 100, 200 and 300 in./in./min. and at temperatures of -65°F, 70°F, 250°F, 600°F and 800°F.

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1.3.4	Figure 1-4, 10,000 Lb. Rapid Loading Machine (Elevated Temperature)	Negative No. 2A65737
1.3.5	Figure 1-5, Test Setup (Preliminary Phase)	Negative No. 2A63041
1.3.6	Figure 1-6, Cryogenic Setup	Negative No. 2A65735
1.3.7	Figure 1-7, Elevated Temperature Setup	Negative No. 2A65738

[1] Refer to D2-6783-1 Structural Integrity Development and Test Program - Detail Plan - Structures Technology

1.4 INTRODUCTION

1.4.1 This report is the result of work accomplished on EWA 5-637*, Reference 1.3.1. This work was required to obtain emperical data for determining the optimum material for the X-20 landing gear energy strap absorption system. Using yielding metal as a means for absorbing landing impact energy required a material which would display uniform elongation and stress characteristics over the applicable range of landing temperatures and dynamic loading rates.

*Refer to D2-6783-1 Structural Integrity Development and Test Program - Detail Plan - Structures Technology

1.5 TEST SPECIMEN

1.5.1 The test specimens were fabricated per Reference 1.3.2. A sketch of the test specimen is shown as Figure 1-1.

1.5.2 The specimens were removed from the sheets as shown in Figure 1-2, and were machined with the grain direction parallel to the test load (longitudinal).

1.5.3 Material information and chemical analysis data are tabulated on Tables 1-1 and 1-2.

1.6 TEST SETUP AND INSTRUMENTATION

1.6.1 Tests were conducted in the Boeing designed 10,000 pound capacity rapid loading tensile machine (see Figures 1-3 and 1-4). The specimens were loaded by a hydraulic cylinder actuated by a servo-valve which responded to an electrical signal.

1.6.2 The proper strain rate (ram speed) was obtained by controlling the fluid flow at the hydraulic pump. The flow of oil was initiated by either a Cadillac or a Sanders servo control valve in conjunction with an electronic timer circuit. In the preliminary phase, the strain was recorded on film with a 1,000 frame/second Eastman High Speed motion picture camera (see Figure 1-5) and measured with the aid of a Vanguard, Model No. M-16, analyzer. In the final phase, the elongation was measured by a pair of Crescent variable permeance gages attached over a two inch gage length (see Figures 1-6 and 1-7).

1.6.3 The specimens tested at 0.005 in./in./min. were loaded in a 12,000 pound capacity Baldwin Universal test machine. The machine was equipped with a Model MA-1 autographic load strain recorder. A Baldwin strainpacer was used to insure a proper average strain rate. The strain to failure was measured using a Baldwin TSMD dual range extensometer.

1.6.4 Cryogenic tests were conducted in a Boeing designed cryogenic chamber, using liquid nitrogen as the coolant (see Figure 1-3 and 1-6). Elevated temperatures were obtained using an Inconel strip heater powered by a variac controlled 50 KVA Research Inc. ignitron power supply (see Figure 1-4 and 1-7). Specimen temperatures were controlled manually at elevated temperature either by positioning the heater with respect to the specimen or by adjusting the heater current. In the cryogenic tests, specimen temperatures were achieved by controlling the flow of liquid nitrogen.

1.6.5 Chromel-alumel thermocouples spotwelded to the specimen were used in conjunction with a Leeds and Northrup strip chart recorder to measure specimen temperatures.

1.7 TEST PROCEDURES

1.7.1 Ninety-five (95) tensile specimens were tested in the preliminary phase of this program. The materials tested included Inconel, "A" Nickel, Hastelloy X, 19-9DL, and 304 ELC. The specimens were loaded to failure in tension at strain rates and temperatures shown in Table 1-3. The purpose of this phase of testing was to select the two most prospective energy strap materials of those tested for final screening.

1.7.2 The final screening included tests of sixty (60) tensile specimens each of the selected materials (Inconel and "A" Nickel). The specimens were loaded at strain rates and temperatures shown in Table 1-3 to approximately one-third of the estimated maximum elongation at rupture and then were completely unloaded. The specimens were then reloaded at the initial strain rate and temperature to failure to determine rebound characteristics of the materials.

1.7.3 The following data was obtained:

(1) stress strain diagrams

(2) energy absorbing capacity at rupture in inch-lbs./lb. of material

(3) energy absorbing capacity at ultimate load in inch-lbs./lb. of material

(4) percent elongation at ultimate

(5) percent elongation at rupture

1.8 TEST RESULTS

1.8.1 Energy absorbing properties and percent elongations are reported on pages 1.21 through 1.29. Stress-strain diagrams are shown on pages 1.30 through 1.99.

1.8.2 Calculation of energy absorbed at rupture and ultimate load was based on the following formula:

$$E = \frac{A}{D}$$

where

A = Area under stress strain curve in $lbs/in.^2$

D = Density of material in $lbs./in.^3$

and

E = Energy absorbed in $\frac{in.-lb.}{lb.}$

1.8.3 The percent elongation at rupture and ultimate strength was measured directly from the stress-strain curves.

1.8.4 The percent of ultimate elongation at rebound was based on the following relationship:

$$\left(\frac{\text{Strain at Rebound}}{\text{Strain at Rupture}}\right) 100$$

1.9 TEST OBSERVATIONS

The test objects were met and the test equipment operated satisfactorily.

TABLE 1-1

MATERIAL INFORMATION

MATERIAL	GAGE -INCHES	MANUFACTURER	HEAT NO.	DENSITIES LBS/IN.^{3}	HEAT TREAT ▽
"A" Nickel	0.109	International Nickel Company	N2546A4	0.3211	(A)
Inconel	0.127	Unknown	Unknown	0.3039	(B)
Hastelloy X	0.125	Continental Metals Inc.	X-106	0.2991	(C)
19-9DL	0.125	Continental Metals Inc.	B82200	0.2876	(D)
304 ELC	0.114	Unknown	Unknown	0.2850	(E)

▽

(A) Solution treat 1800°F (±25°F) for 20 minutes then air quench.

(B) Solution treat 1960°F (±25°F) for 20 minutes then water quench.

(C) Solution treat 2150°F (±25°F) for 20 minutes then water quench.

(D) Solution treat 1950°F (±25°F) for 20 minutes then water quench.

(E) Solution treat 1950°F (±25°F) for 20 minutes then water quench.

TABLE 1-2

CHEMICAL ANALYSIS OF MATERIALS

ELEMENT	NICKEL "A"	INCONEL	HASTELLOY X	D-19-9DL	304 ELC
Cr	—	14.17%	21.63%	19.10%	18.79%
Ni	99.16%	76.32%	—	10.02%	10.45%
Mo	—	—	8.78%	1.60%	—
W	—	—	0.82%	1.52%	—
Cb + Ta	—	—	—	0.60%	—
Ti	—	—	—	0.28%	—
Fe	0.21%	7.03%	17.21%	—	—
Si	0.20%	0.31%	0.60%	0.67%	0.71%
Mn	0.28%	0.13%	0.02%	0.97%	1.02%
Cu	0.18%	0.22%	—	Trace	—
Co	—	0.30%	0.90%	—	—
C	0.019%	0.030%	0.11%	0.31%	0.005%
S	0.005%	—	0.006%	0.015%	0.019%
P	—	—	0.002%	0.030%	0.021%

TABLE 1-3

TEST OUTLINE

PRELIMINARY SCREENING

MATERIAL	STRAIN RATE IN./IN./MIN.	TEMPERATURE °F
Inconel	.005	-65
	.005	72
	190	72
	180	600
	200	800
	290	72
Inconel	290	800
Hastelloy X	.005	-65
	.005	72
	200	-65
	170	72
	185	600
	300	-65
	295	72
Hastelloy X	285	800
Nickel "A"	.005	-65
	.005	72
	200	-65
	180	72
	190	600
	300	-65
	280	72
Nickel "A"	280	800
19-9DL	.005	72
	180	72
	185	600
	295	72
19-9DL	295	800
304 ELC	.005	72
	200	72
	200	600
	300	72
304 ELC	285	800

TABLE 1-4
TEST OUTLINE
FINAL SCREENING

MATERIAL	STRAIN RATE IN./IN./MIN.	TEMPERATURE °F
Inconel	.005-.05	250
		600
		800
	50	-65
		72
		250
		600
		800
	100	-65
		72
		250
		600
		800
	200	-65
		250
		800
	300	-65
		250
Inconel		600
Nickel "A"	.005-.05	250
		600
		800
	50	-65
		72
		250
		600
		800
	100	-65
		72
		250
		600
		800
	200	250
		800
	300	250
Nickel "A"		600

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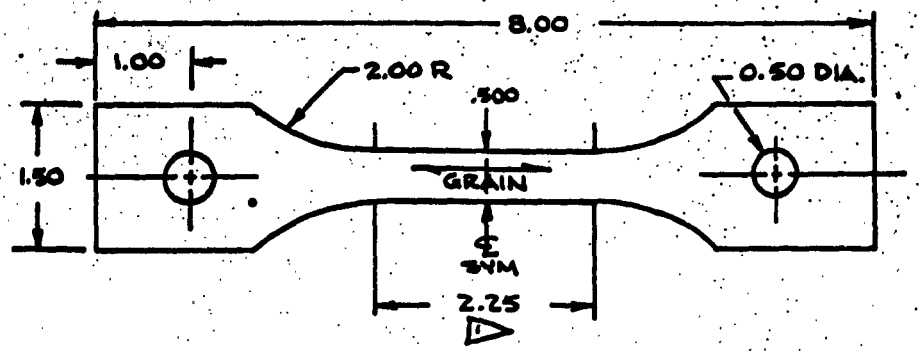
FIGURE 1-1

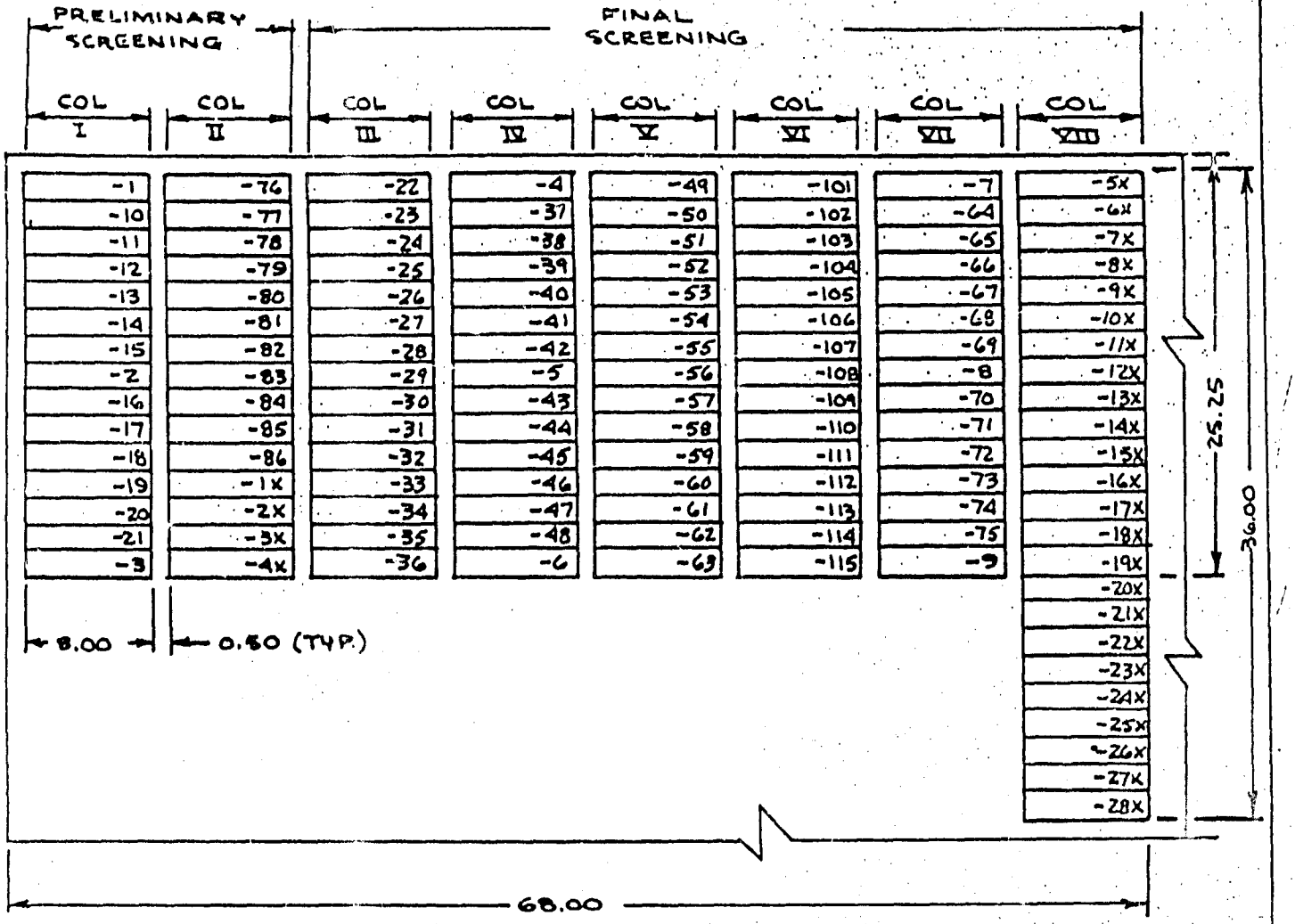
TENSILE SPECIMEN
(REF. BOEING DWG 23-4164)



1 STRAIN AND ELONGATION MEASURED OVER A 2 INCH SECTION WITHIN INDICATED GAGE SECTION.

FIGURE 1-2

SHEET LAYOUT & SPECIMEN NUMBERING CODE



MATERIAL	PRE-FIX	USAGE
"A" NICKEL	A	1
INCONEL	B	4
HASTELLOY X	C	2
19-9 DL	D	3
304 ELC	E	3

1. PRELIM. & FINAL SCREENING (COL I THRU COL VII)
2. PRELIM. SCREEN. (COL I & II)
3. PRELIM. SCREEN. (COL I & II) (NOT INCLUD. SPEC'S -1X THRU -4X)
4. PRELIM. & FINAL SCREENING (COL I THRU VIII, NOT INCLUD. -1X THR-9X)

TYP. SPECIMEN NO.

A - 22

"A" NICKEL — DASH NO.

TYP SPECIMEN NO.

B - 5X

INCONEL — DASH NO.

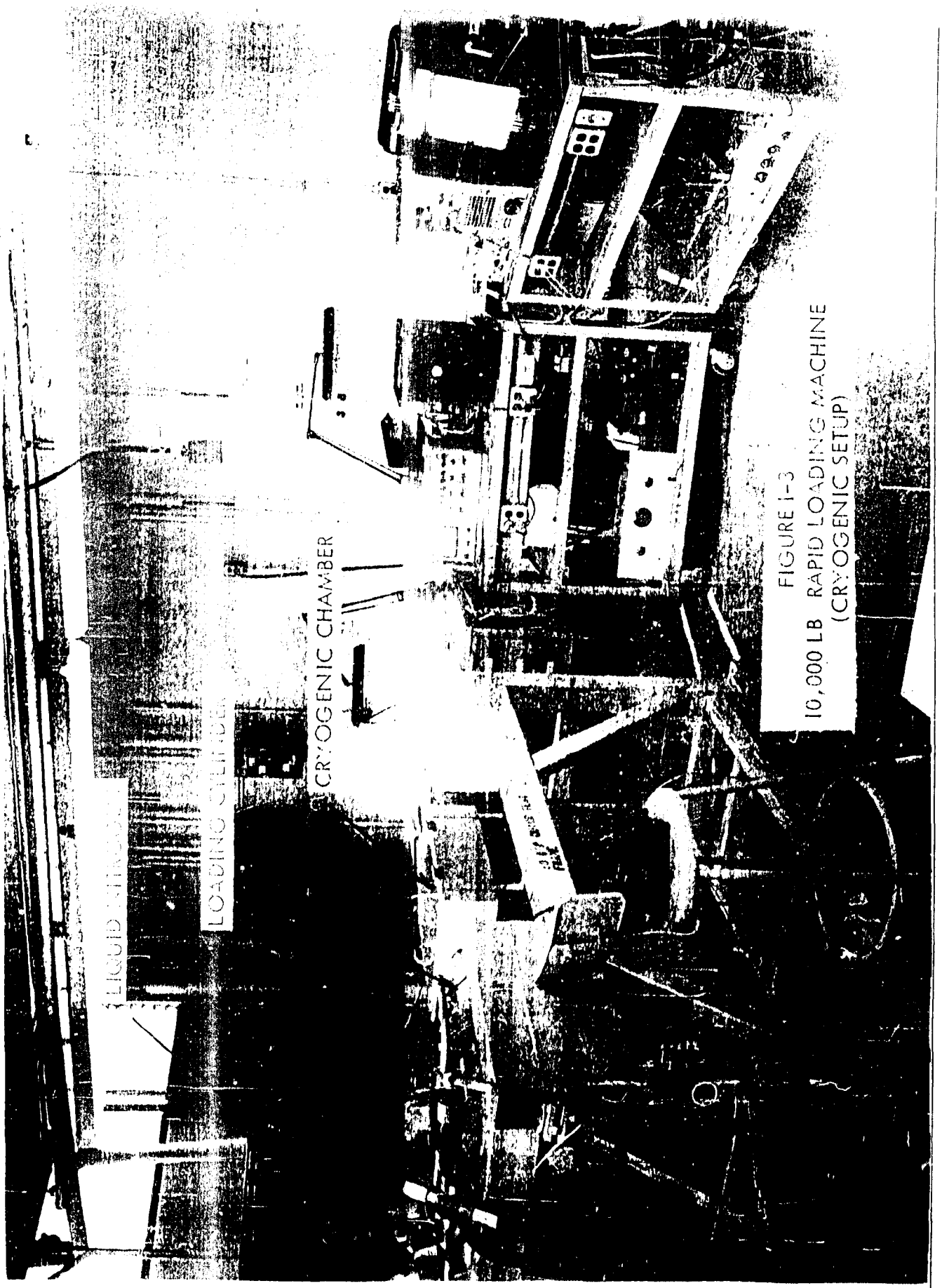


FIGURE I-3
10,000 LB RAPID LOADING MACHINE
(CRYOGENIC SETUP)

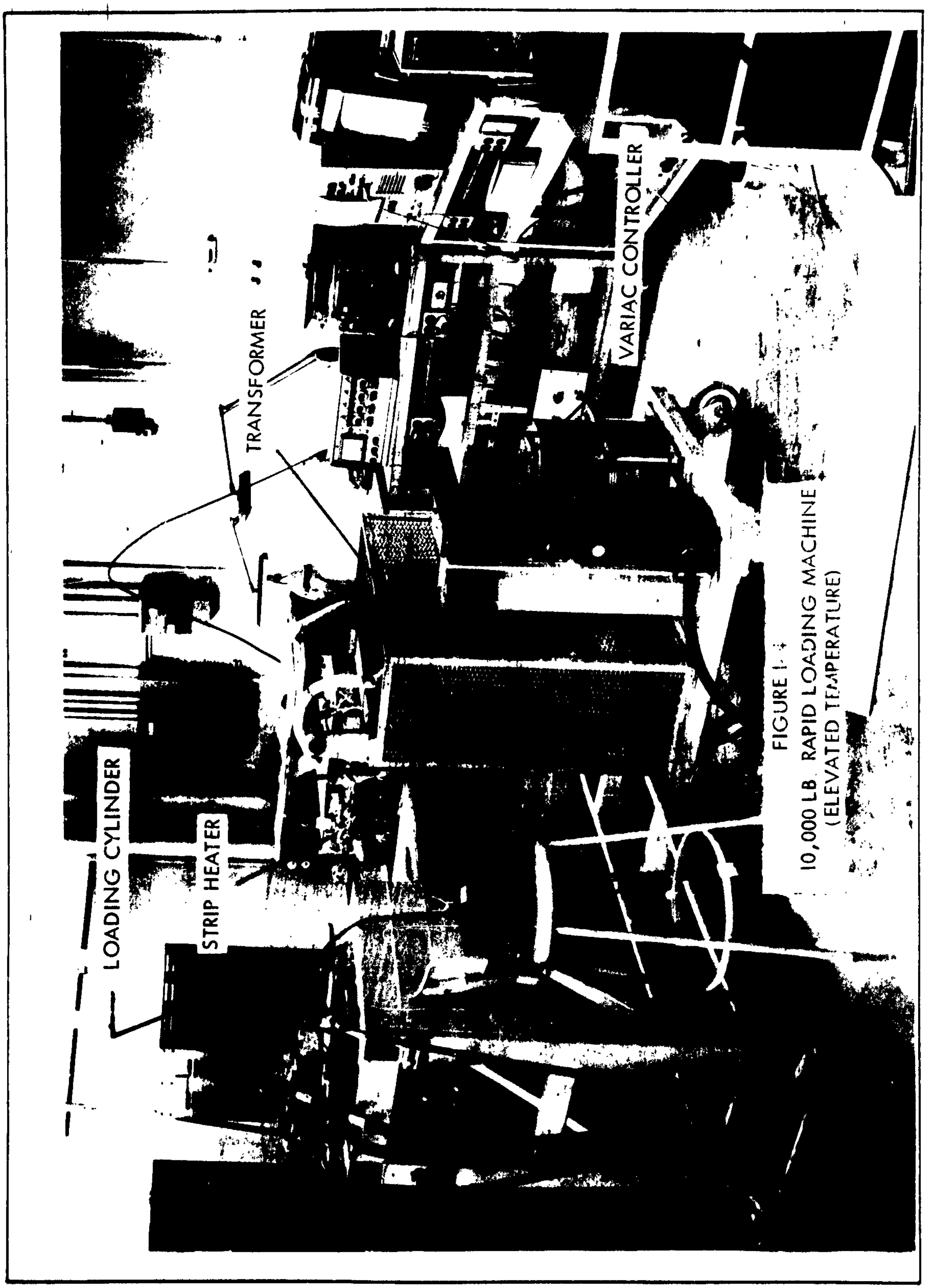


FIGURE 1-4
10,000 LB. RAPID LOADING MACHINE
(ELEVATED TEMPERATURE)

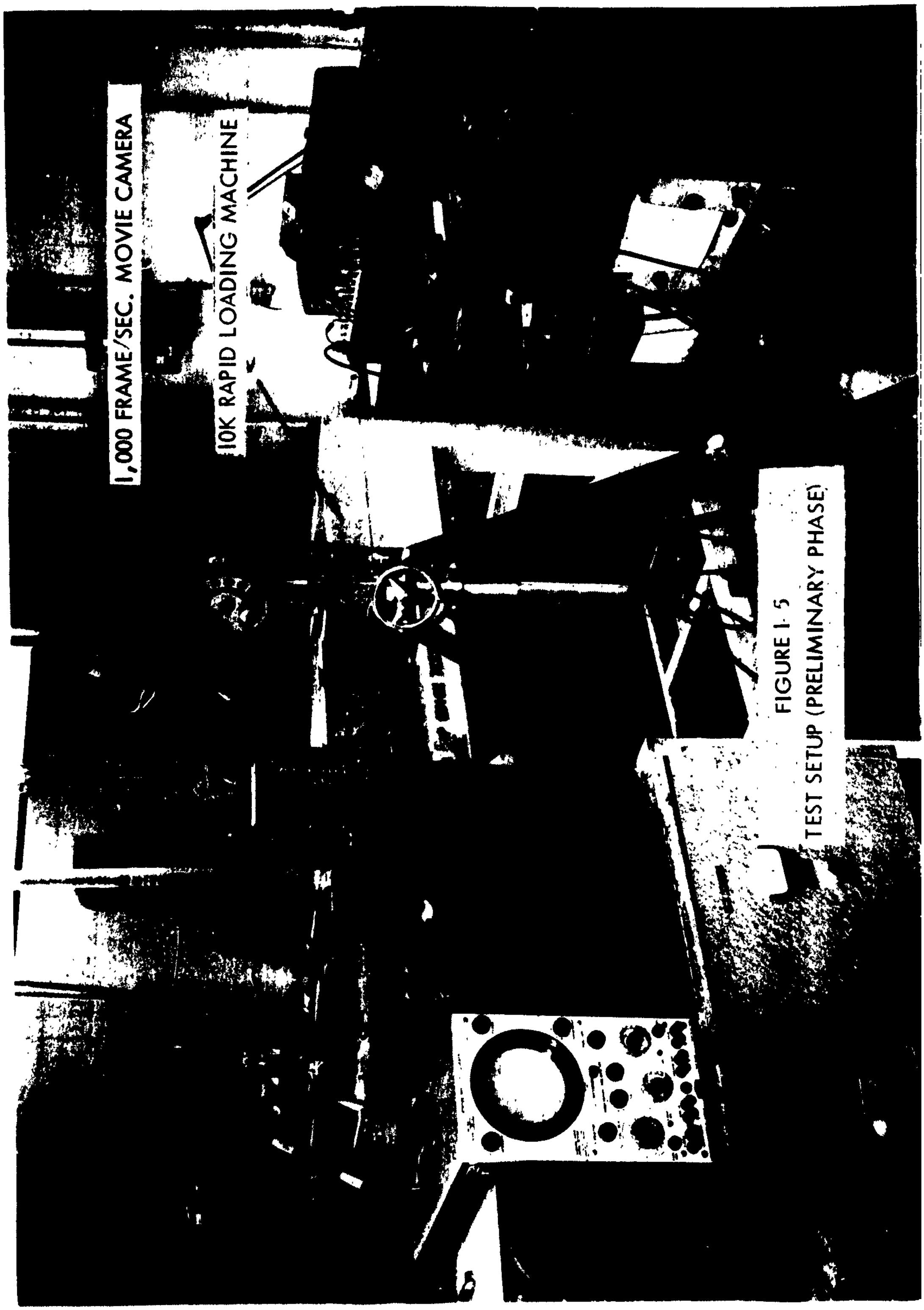


FIGURE 1-5
TEST SETUP (PRELIMINARY PHASE)

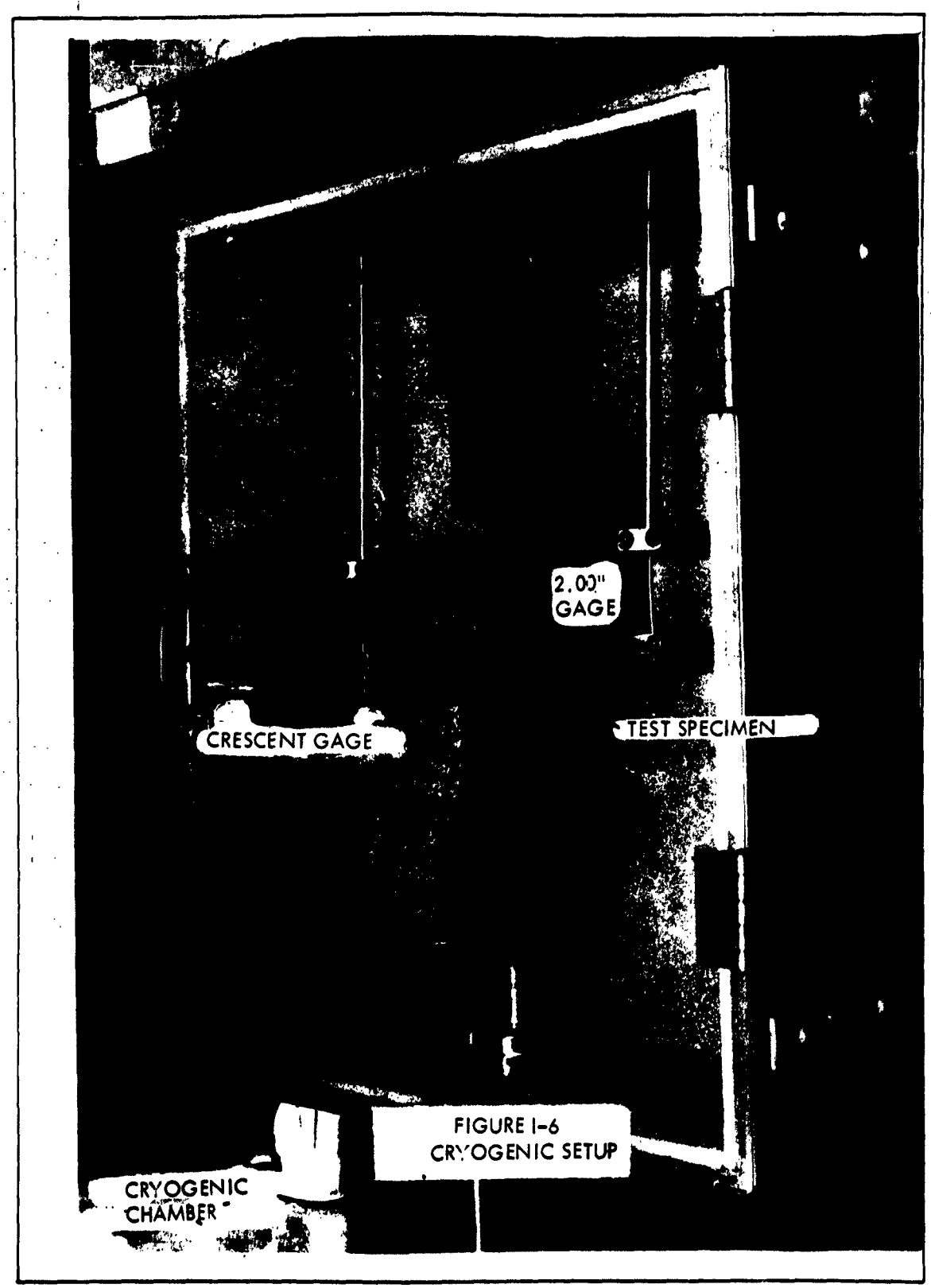


FIGURE I-6
CRYOGENIC SETUP

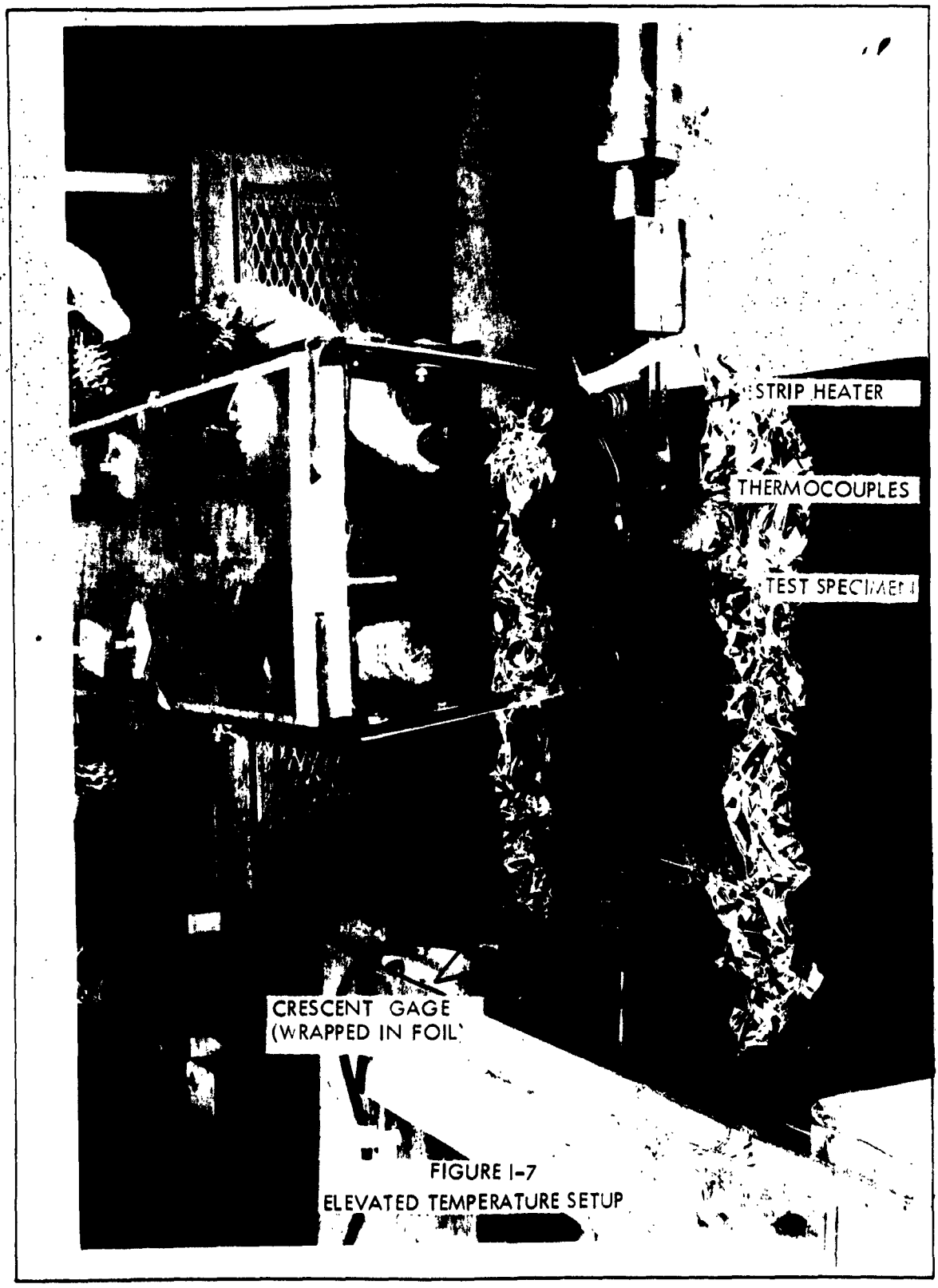


FIGURE I-7
ELEVATED TEMPERATURE SETUP

NOTES

1. Energy computations were based on the following densities,

   Nickel "A" = 0.321 lbs./in.^{3}

   Inconel = 0.300 lbs./in.^{3}

   Hastelloy X = 0.290 lbs./in.^{3}

   304 ELC = 0.290 lbs./in.^{3}

   19-9DL = 0.287 lbs./in.^{3}

2. Preliminary Screening. Specimens tested in the preliminary screening phase were loaded directly to failure.

3. Final Screening. Elongation was not obtained for the specimens tested in the final screening phase.

4. Total Measured Elongation.

5. % elongation on which energy to FTU (Stress, Tensile Ultimate, PSI) is based.

FTU - Ultimate Tensile Force, PSI

SPECIMEN NUMBER	% OF ULT. ELONG. AT REBOUND	AREA ~IN²~	TEST TEMPERATURE ~°F~	STRAIN RATE ~IN/IN/MIN~	ULTIMATE STRENGTH ~PSI~	% ELONGATION TO FTU	ENERGY TO FTU ~IN-LBS/LB (1)	% ELONGATION TO FAILURE	ENERGY TO FAILURE ~IN-LBS/LB (1)	TOTAL MEASURED ELONGATION ~%~
A-82	(2)	.0535	-65	.005	58,400	42.0	61,400	49.0	74,400	50.0
A-83		0535	↓	↑	60,900	46.0	70,700	51.0	81,600	52.0
A-84		.0540	-65		60,000	42.0	62,300	49.0	73,800	49.0
A-79		.0535	72		52,000	47.0	58,735	50.0	63,235	50.0
A-80		.0543	↓		53,500	46.0	59,681	49.0	64,125	49.0
A-81	(2)	.0542	72	.005	53,500	46.0	60,782	48.0	65,362	46.0
A-101	38.7	.0528	250	(A) .005	48,300	39.0	47,500	(3)	53,250	44.0
A-103	30.0	.0529	↓	↑	49,300	39.5	50,200		57,400	46.0
A-104	32.8	.0534	250		48,500	39.5	49,900		57,800	46.0
A-4	41.2	.0529	600	(B) .05	43,700	35.0	38,800		44,700	40.0
A-6	41.2	.0542	↓	↑	43,500	35.0	38,900		44,200	40.0
A-105	73.2	.0533	600		44,100	36.0	40,500		46,200	41.0
A-8	34.1	.0543	800		35,000	40.0	38,200		44,400	47.0
A-9	33.0	.0551	↓		35,500	35.0	32,600		42,200	45.5
A-106	34.4	.0539	800	.005 .05	34,500	35.0	32,100		40,100	45.0
A-40	14.6	.0536	72	50	56,000	43.0	61,700		67,800	48.0
A-41	15.2	.0531	↓	↑	57,000	41.0	60,500		68,500	46.0
A-42	17.0	.0533	72		57,000	41.0	60,000		69,000	47.0
A-36	17.4	.0541	250		51,000	37.0	48,500		56,700	45.0
A-37	18.1	.0532	↓		51,000	40.0	53,000		61,200	47.5
A-38	30.6	.0533	250		51,900	38.0	51,200		58,500	45.0
A-51	37.5	.0532	600		44,000	33.5	38,000		44,200	40.0
A-52	33.4	.0534	↓		44,000	31.0	34,300		42,300	39.0
A-109	33.4	.0539	600		46,000	32.0	37,100		44,700	39.0
A-64	30.6	.0527	800		40,000	34.5	36,200		40,400	38.0
A-65	30.6	.0527	↓		41,000	35.0	38,100		42,200	39.0
A-66	40.0	.0535	800	50	41,000	33.5	36,000	(3)	39,400	37.5

~ SEE PAGE 1-20 FOR NOTES ~

CALC	STRICKLAND	4/18/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES	X-20A
CHECK	KOPPERSTAD	4/25/63			NICKEL "A" (LOW CARBON)	
APR					0.109 GAGE SHEET	D2-80086
APR					THE BOEING COMPANY	PAGE 1-21

SPECIMEN NUMBER	% OF ULT. ELONG. AT REBOUND	AREA ~IN²~	TEST TEMPERATURE ~°F~	STRAIN RATE ~IN/IN/MIN~	ULTIMATE STRENGTH ~PSI~	% ELONGATION TO FTU	ENERGY TO FTU ~IN-LBS/LB (1)	% ELONGATION TO FAILURE	ENERGY TO FAILURE ~IN-LBS/LB (1)	TOTAL MEASURED ELONGATION ~%
A-27	26.0	.0534	-65	50	61,000	42.5	68,100	(3)	80,800	52.0
A-28	33.0	.0533	↑	↓	62,000	41.0	66,000	↑	78,900	50.0
A-29	34.6	.0536	↓	50	63,000	45.0	73,900	↓	82,000	50.5
A-23	29.3	.0533	↓	100	64,000	43.0	72,300	↓	86,400	51.5
A-24	30.0	.0534	↓	↑	64,000	42.5	69,000	↓	81,400	50.0
A-25	31.8	.0534	-65	↑	65,000	44.0	73,100	↓	85,200	52.0
A-43	33.0	.0538	72	↓	58,000	45.5	70,300	↓	75,400	50.0
A-44	36.0	.0539	↑	↓	59,000	46.5	72,700	↓	76,400	50.0
A-56	38.0	.0542	72	↓	58,000	45.0	69,100	↓	74,500	50.0
A-27	32.0	.0541	250	↓	52,000	41.0	57,300	↓	64,000	47.0
A-58	34.0	.0545	↑	↓	52,000	41.0	56,400	↓	63,100	47.0
A-59	38.3	.0543	250	↓	53,000	40.0	55,000	↓	62,400	47.0
A-53	34.2	.0532	600	↓	46,000	37.0	43,900	↓	47,300	41.0
A-54	28.1	.0536	↑	↓	45,000	35.5	42,900	↓	46,500	41.0
A-55	29.3	.0539	600	↓	44,000	36.0	41,600	↓	46,000	41.0
A-68	33.2	.0539	800	↓	42,000	34.0	39,200	↓	42,400	38.0
A-69	33.0	.0544	↑	↓	41,000	36.0	39,800	↓	42,900	39.5
A-70	26.5	.0545	800	100	41,000	38.0	42,300	(3)	44,800	41.5
A-10	(2)	.0549	72	180	57,000	41.0	56,100	53.0	74,900	51.0
A-11	↑	.0549	↑	↑	55,700	46.0	60,500	47.0	62,100	49.0
A-12	↓	.0538	72	180	58,600	48.0	68,600	50.0	71,100	51.0
A-16	↓	.0544	600	190	43,800	35.0	34,400	37.0	36,100	40.0
A-18	↓	.0551	↑	↑	41,900	31.0	29,600	34.0	32,400	37.0
A-76	↓	.0549	600	190	41,300	31.0	30,200	33.0	31,200	36.0
A-1-X	↓	.0535	-65	200	63,000	42.6	68,440	49.0	74,330	49.0
A-2-X	↓	.0532	↑	↑	62,000	43.8	69,250	51.0	76,730	51.0
A-78	(2)	.0534	-65	200	64,000	47.0	78,970	50.0	83,120	50.0

~SEE PAGE 1-20 FOR NOTES~

CALC	STRICKLAND 4/19/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES NICKEL "A" (LOW CARBON) 0.109 GAGE SHEET	X-20A
CHECK	KOPPERSTAD 4/25/63				D2-80086
APP					
APP				THE BOEING COMPANY	PAGE 1-22

SPECIMEN NUMBER	% OF ULT. ELONG. AT REBOUND	AREA ~IN²~	TEST TEMPERATURE ~°F~	STRAIN RATE ~IN/IN/MIN~	ULTIMATE STRENGTH ~PSI~	% ELONGATION TO FTU	ENERGY TO FTU (1) ~IN-LBS/LB	% ELONGATION TO FAILURE	ENERGY TO FAILURE (1) ~IN-LBS/LB	TOTAL MEASURED ELONGATION ~%~
A-33	35.4	.0535	250	200	53,000	42.5	59,200	(3)	65,200	48.0
A-35	43.2	.0538	↑	↑	53,000	42.5	59,800	↑	64,200	47.5
A-67	37.0	.0538	250	↑	53,000	42.5	59,800	↑	64,200	46.0
A-71	32.2	.0547	800	↓	41,000	36.5	40,000	↓	44,250	42.0
A-74	23.8	.0548	↓	↓	41,000	36.5	39,400	↓	44,100	42.0
A-75	11.9	.0548	800	200	41,000	37.0	39,600	(3)	44,250	42.0
A-3-X	(2)	.0531	-65	300	64,000	44.5	73,990	51.0	81,310	51.0
A-4-X	↓	.0528	-65	↑	63,000	40.5	63,490	46.0	69,780	46.0
A-46	↓	.0528	250	↓	56,000	42.0	61,000	48.5	68,750	48.5
A-47	↓	.0534	↓	↓	56,000	45.0	64,800	49.0	69,850	49.0
A-49	↓	.0528	250	↓	56,000	39.5	56,900	49.0	68,250	49.0
A-60	↓	.0542	600	↓	45,000	37.0	42,900	42.5	48,200	42.5
A-61	↓	.0545	↓	↓	45,000	37.0	43,100	42.0	47,500	42.0
A-62	↓	.0536	600	300	46,000	36.0	43,250	40.0	47,000	40.0
A-13	↓	.0547	72	280	56,800	42.0	55,500	45.0	60,500	48.0
A-14	↓	.0546	↑	↑	56,600	39.0	50,000	42.0	54,900	43.0
A-15	↓	.0547	72	↑	56,800	41.0	56,000	42.0	57,500	46.0
A-20	↓	.0552	800	↓	42,200	29.0	26,200	32.0	30,800	35.0
A-21	(2)	.0552	800	280	42,200	34.0	32,600	37.0	36,800	39.0

~ SEE PAGE 1-20 FOR NOTES ~

CALC	STOCKLAND	6/19/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES NICKEL "A" (LOW CARBON) 0.109 GAGE SHEET	X-20A
CHECK	Kapperstad	9/25/63				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 1-23

US 1930 8008

SPECIMEN NUMBER	% OF ULT. ELONG. AT REBOUND	AREA ~IN²~	TEST TEMPERATURE ~°F	STRAIN RATE ~IN/IN/MIN	ULTIMATE STRENGTH ~PSI~	% ELONGATION TO FTU	ENERGY TO FTU ~IN-LBS/LB (1)	% ELONGATION TO FAILURE	ENERGY TO FAILURE ~IN-LBS/LB (1)	TOTAL MEASURED ELONGATION ~%
B-84	(2)	.0640	-65	.005	96,900	42.0	170,000	46.0	120,000	46.0
B-85		.0640			94,300	45.0	106,800	52.0	127,500	52.0
B-86		.0640	-65		97,200	40.0	98,400	44.0	113,700	46.0
B-1		.0644	72		86,000	45.0	102,107	51.0	119,367	50.0
B-2		.0648			87,000	45.0	99,278	51.0	115,168	49.0
B-3	(2)	.0645	72	.005	85,600	46.0	101,261	50.0	113,701	49.0
B-8X	35.8	.0635	250	.005 .05	79,700	40.5	81,800	(3)	92,200	46.0
B-19X	44.7	.0631			79,200	42.5	86,200		95,700	47.0
B-23X	34.7	.0635	250		79,100	43.0	88,100		97,100	47.0
B-24X	28.6	.0639	600		79,600	54.0	110,200		115,200	56.0
B-25X	28.8	.0639			79,500	53.0	105,800		112,300	55.5
B-26X	29.4	.0633	600		79,900	53.6	107,700		115,300	56.5
B-14X	42.1	.0637	800		78,200	54.0	107,100		114,400	57.0
B-15X	29.2	.0641			78,300	56.0	112,700		120,700	59.0
B-16X	32.1	.0638	800	.005 .05	78,000	55.0	108,700	(3)	115,800	58.0
B-23	(2)	.0634	-65	50	98,000	43.0	115,500	50.0	131,800	50.0
B-25		.0637			98,000	40.2	104,100	47.0	116,300	47.0
B-102		.0631	-65		100,000	34.5	92,000	46.0	116,000	46.0
B-42		.0641	R.T.		88,000	44.5	106,400	50.0	117,000	50.0
B-49		.0628			92,000	39.5	102,000	45.0	113,500	45.0
B-110		.0629	R.T.		90,000	43.0	105,000	51.0	121,500	51.0
B-111		.0633	250		84,000	39.0	89,600	42.0	95,400	42.0
B-112		.0637			84,000	40.0	90,300	44.0	98,700	44.0
B-113		.0632	250		92,000	38.5	98,500	43.5	109,500	43.5
B-52		.0638	600		74,000	39.0	74,900	46.0	87,000	46.0
B-63		.0635			78,000	39.0	80,500	46.0	91,600	46.0
B-77	(2)	.0640	600	50	80,000	39.5	83,000	46.5	99,000	46.5

~SEE PAGE 1-20 FOR NOTES~

CALC	STRICKLAND	4/19/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES INCONEL NICKEL BASE ALLOY 0.127 GAGE SHEET	X-20A
CHECK	KOPPERSTAD	4/25/63				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 1-24

US 4030 0000

SPECIMEN NUMBER	% OF ULT. ELONG. AT REBOUND	AREA ~IN²	TEST TEMPERATURE ~°F	STRAIN RATE ~IN/IN/MIN	ULTIMATE STRENGTH ~PSI	% ELONGATION TO FTU	ENERGY TO FTU ~IN-LBS/LB (1)	% ELONGATION TO FAILURE	ENERGY TO FAILURE ~IN-LBS/LB (1)	TOTAL MEASURED ELONGATION ~%
B-65	(3)	.0636	800	50	76,000	47.5	95,000	53.0	104,000	53.0
B-66		.0638			80,000	40.0	88,500	47.0	96,400	47.0
B-115		.0637	800	50	80,000	39.0	79,100	45.0	90,600	45.0
B-104		.0636	-65	100	104,000	40.0	113,900	48.0	131,600	48.0
B-28		.0644			98,000	44.5	120,900	50.0	136,500	50.0
B-30	(3)	.0644	-65		98,000	44.0	116,900	51.0	130,000	51.0
B-44	41.6	.0637	72		94,000	44.0	114,800	(3)	123,000	48.0
B-45	41.5	.0637			96,000	41.0	110,000		123,000	47.0
B-75	35.1	.0636	72		100.000	40.0	111,800		124,900	47.0
B-57	23.4	.0641	250		84,000	40.0	93,100		103,000	45.0
B-59	22.8	.0637			84,000	42.0	97,700		107,300	46.0
B-70	23.8	.0631	250		84,000	42.5	99,700		107,500	46.5
B-73	46.0	.0632	600		84,000	37.0	89,500		96,500	43.5
B-55	39.9	.0637			80,000	40.0	85,600		90,400	44.0
B-58	37.2	.0640	600		78,000	40.6	82,500		88,400	43.0
B-67	27.0	.0636	800		78,000	44.5	91,600		100,500	50.0
B-68	30.2	.0636			82,000	39.0	86,800		94,500	43.0
B-69	26.0	.0639	800	100	78,000	46.0	95,000	(3)	102,500	50.0
B-16	(2)	.0646	600	180	75,670	40.0	74,000	44.0	85,400	43.0
B-17		.0643	600	180	73,960	41.0	78,600	46.0	86,700	45.0
B-10		.0646	72	190	88,500	47.0	106,700	49.0	113,200	52.0
B-11		.0641			86,100	46.0	110,000	47.0	111,600	47.0
*B-12		.0640	72	190	97,300	44.0	128,000	45.0	128,200	48.0
B-33		.0640	-65	200	104,000	39.5	112,700	46.0	125,300	46.0
B-107		.0638			98,000	44.0	120,700	50.0	132,000	50.0
B-34	(2)	.0640	-65	200	100,000	44.0	120,300	51.0	136,800	51.0

~ SEE PAGE I-20 FOR NOTES ~

CALC	STRICKLAND	4/22/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES INCONEL NICKEL BASE ALLOY .0.127 GAGE SHEET	X-20A
CHECK	KOPPERSTAM	4/25/63				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE I-25

U3 4038 8000

SPECIMEN NUMBER	% OF ULT. ELONG. AT REBOUND	AREA ~IN²	TEST TEMPERATURE ~°F	STRAIN RATE ~IN/IN/MIN	ULTIMATE STRENGTH ~PSI	% ELONGATION TO FTU	ENERGY TO FTU (1) ~IN-LBS/LB	% ELONGATION TO FAILURE	ENERGY TO FAILURE (1) ~IN-LBS/LB	TOTAL MEASURED ELONGATION ~%
B-4	(2)	.0636	72	200	98,000	37.5	111,900	46.0	121,000	46.0
B-5	↓	.0638	↑	↑	96,000	40.5	113,900	46.0	120,000	46.0
B-6	(2)	.0636	72	↑	94,000	40.5	110,000	46.0	116,000	46.0
B-7	14.7	.0633	250	↑	88,000	39.5	92,700	(3)	106,700	47.0
B-17X	32.3	.0622	↑	↑	88,000	43.0	104,000	↑	116,300	48.0
B-80	33.3	.0637	250	↑	90,000	39.0	94,600	↑	108,200	45.0
B-18X	34.6	.0628	800	↑	76,000	43.0	85,600	↓	95,700	48.0
B-72	33.8	.0635	↑	↑	79,000	42.0	84,900	↓	97,400	48.0
B-73	35.0	.0639	800	200	82,000	35.5	80,100	(3)	88,900	40.0
B-13	(3)	.0645	72	290	94,300	42.0	100,500	43.0	104,200	46.0
B-14	↑	.0639	↑	↑	91,800	42.0	101,000	43.0	104,900	46.0
B-15	↑	.0646	72	↑	90,600	40.0	92,000	43.0	99,000	44.0
B-19	↑	.0647	800	↑	74,900	44.0	76,500	45.0	80,870	45.0
B-20	↑	.0648	↑	↑	73,000	43.0	78,700	44.0	79,500	44.0
B-21	↑	.0647	800	290	76,500	44.0	82,470	49.0	94,370	50.0
B-31	↑	.0632	-65	300	104,000	40.5	116,700	47.0	129,400	47.0
B-38	↑	.0637	↑	↑	98,000	44.5	122,600	52.0	136,000	52.0
B-106	↑	.0632	-65	↑	98,000	42.0	113,300	51.0	128,900	51.0
B-46	↑	.0639	250	↑	84,000	44.0	101,500	49.0	111,700	49.0
B-47	↑	.0642	↑	↑	88,000	41.0	96,600	44.0	102,700	44.0
B-48	↑	.0632	250	↑	90,000	42.0	103,000	45.5	110,500	45.5
B-60	↑	.0635	600	↑	84,000	35.0	79,200	49.0	86,500	49.0
B-61	↓	.0638	↑	↑	76,000	41.0	83,200	43.5	88,900	43.5
B-62	(2)	.0631	600	300	78,000	38.0	79,600	41.0	87,500	41.0

~SEE PAGE 1-20 FOR NOTES~

CALC	STRICKLAND	4/22/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES INCONEL NICKEL BASE ALLOY 0.127 GAGE SHEET	X-20A
CHECK	KOPPERSTAD	4/25/63				D2-80086
APR					THE BOEING COMPANY	PAGE 1-26
APR						

US.4030.0000

SPECIMEN NUMBER	AREA ~IN²	TEST TEMPERATURE ~°F	STRAIN RATE ~IN/IN/MIN.	ULTIMATE STRENGTH ~PSI	% ELONGATION TO FTU	ENERGY TO FTU ~IN-LBS/LB (1)	% ELONGATION TO FAILURE	ENERGY TO FAILURE ~IN-LBS/LB (1)	TOTAL MEASURED ELONGATION ~%
C-82	.0634	-65	.005	126,000	43.0	163,600	51.0	202,000	47.0
C-83	.0636	↕	↕	129,800	38.0	138,800	42.0	156,200	43.0
C-84	.0633	-65	↓	124,000	40.0	146,700	44.0	163,000	44.0
C-79	.0661	72	↓	110,700	42.0	141,300	46.0	151,000	43.0
C-80	.0660	↕	↕	111,200	41.0	134,768	46.0	151,268	43.0
C-81	.0658	↓	.005	111,100	41.0	134,037	47.0	147,863	43.0
C-12	.0661	↓	140	117,000	42.0	140,400	44.0	146,000	43.0
C-10	.0663	↓	170	110,400	42.0	130,900	43.0	142,400	46.0
C-11	.0660	72	170	109,100	41.0	127,300	43.0	137,000	46.0
C-16	.0631	600	185	90,450	37.0	88,000	44.0	108,700	44.0
C-17	.0634	↕	↕	93,370	38.0	99,000	42.0	111,800	42.0
C-18	.0632	600	185	89,500	34.0	81,500	36.0	88,700	41.0
C-1-X	.0674	-65	200	130,000	31.7	128,900	37.1	142,900	37.1
C-76	.0659	↕	↕	130,000	30.8	121,050	43.0	148,480	43.0
C-77	.0631	-65	200	130,000	36.8	152,690	43.2	169,240	43.2
C-19	.0656	800	285	90,000	38.0	97,000	39.0	100,200	39.0
C-20	.0656	↕	↕	92,300	40.0	97,000	41.0	101,200	41.0
C-21	.0674	800	285	90,250	41.0	98,300	44.0	105,200	45.0
C-13	.0659	72	295	117,970	43.0	142,800	45.0	150,300	46.0
C-14	.0655	↕	↕	120,610	43.0	142,500	44.0	146,200	45.0
C-15	.0656	72	295	117,350	43.0	146,600	44.0	148,500	46.0
C-2-X	.0631	-65	300	128,000	32.3	130,690	44.0	138,000	44.0
C-3-X	.0648	↕	↕	128,000	30.2	117,240	43.5	147,790	43.5
C-86	.0656	-65	300	130,000	37.8	153,520	40.0	180,760	49.0

~SEE PAGE 1-20 FOR NOTES~

CALC	STRICKLAND	4/22/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES HASTELLOY X NICKEL BASE ALLOY 0.125 GAGE SHEET	X-20A
CHECK	KOPPER	4/24/63				D2-80086
APR					THE BOEING COMPANY	PAGE 1-27
APR						

SPECIMEN NUMBER	AREA ~IN²	TEST TEMPERATURE ~°F	STRAIN RATE ~IN/IN/MIN.	ULTIMATE STRENGTH ~PSI	% ELONGATION TO FTU	ENERGY TO FTU ~IN-LBS/LB (1)	% ELONGATION TO FAILURE	ENERGY TO FAILURE ~IN-LBS/LB (1)	TOTAL MEASURED ELONGATION ~%
D-79	.0678	RT	.005	107,900	39.0	129,071	43.0	141,421	41.0
D-80	.0648	↑	↓	108,300	38.0	123,538	42.0	137,128	40.0
D-81	.0661	↑	.005	106,800	39.0	123,826	42.0	136,336	40.0
D-10	.0661	↓	180	111,000	39.0	127,600	45.0	150,000	46.0
D-11	.0667	↓	↑	109,000	41.0	127,000	44.0	138,700	44.0
D-12	.0663	RT	180	108,400	42.0	138,900	45.0	146,500	46.0
D-16	.0667	600	185	82,090	30.0	68,200	32.0	73,600	33.0
D-17	.0673	↑	↓	81,870	27.0	61,600	30.0	69,200	32.0
D-18	.0669	600	185	82,520	29.0	67,400	32.0	75,600	34.0
D-13	.0666	RT	295	107,900	40.0	125,200	44.0	140,000	46.0
D-14	.0663	↑	↑	108,300	40.0	122,000	42.0	132,000	44.0
D-15	.0665	RT	↑	106,400	41.0	124,000	45.0	141,000	44.0
D-19	.0665	800	↓	81,700	28.0	58,600	30.0	64,300	30.0
D-20	.0672	↑	↓	82,100	27.0	58,100	28.0	61,500	30.0
D-21	.0669	800	295	81,200	27.0	58,100	29.0	63,000	32.0

~SEE PAGE 1-20 FOR NOTES~

CALC	STRICKLAND	4/22/63	REVISED	DATE	ENERGY ABSORBING PROPERTIES 19-9DL 0.125 GAGE SHEET	X-20A
CHECK	[illegible]	4/25/63				D2-80086
APP					THE BOEING COMPANY	PAGE 1-28
APP						

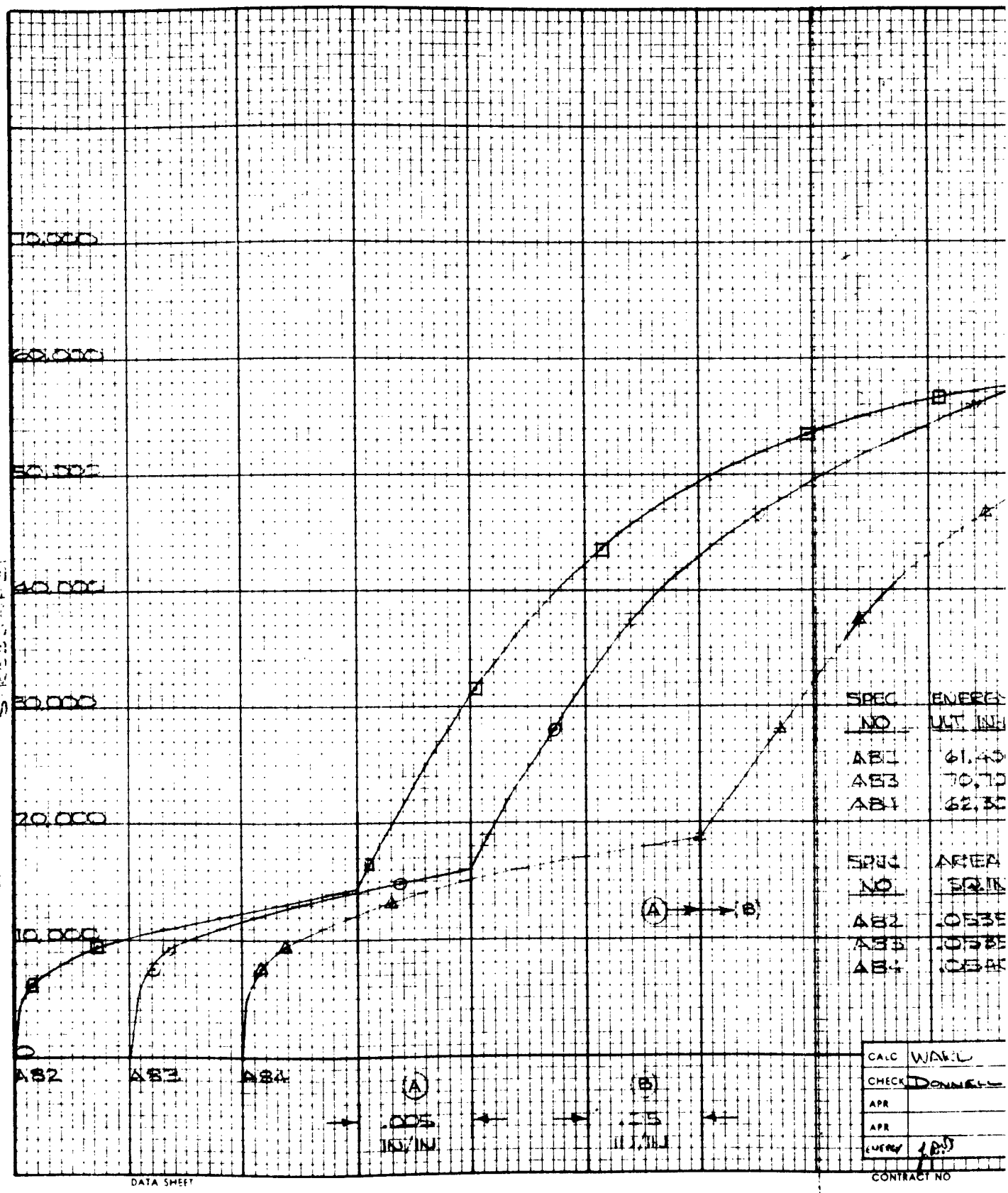
US 4030 0000

SPECIMEN NUMBER	AREA ~IN²	TEST TEMPERATURE ~°F	STRAIN RATE ~IN/IN/MIN	ULTIMATE STRENGTH ~PSI	% ELONGATION TO FTU	ENERGY TO FTU ~IN-LBS/LB [1]	% ELONGATION TO FAILURE	ENERGY TO FAILURE ~IN-LBS/LB [1]	TOTAL MEASURED ELONGATION ~%
E-81	.0363	72	.005	77,400	61.0	138,053	65.0	149,103	65.0
E-82	.0374	↕	↕	77,400	59.0	133,694	63.0	144,094	65.0
E-83	.0370	72	.005	78,000	63.0	138,329	67.0	148,529	67.0
E-11	.0367	72	200	78,000	57.0	134,700	61.0	144,000	63.0
E-18	.0366	600	↕	50,700	37.0	48,500	38.0	50,600	36.0
E-78	.0373	↕	↕	54,000	33.0	49,100	37.0	55,800	38.0
E-79	.0360	600	200	51,300	30.0	38,900	39.0	46,400	36.0
E-19	.0377	800	285	51,200	29.0	42,300	36.0	52,600	36.0
E-20	.0369	↕	↕	52,700	32.0	45,900	38.0	55,200	39.0
E-21	.0371	800	285	52,300	26.0	38,800	36.0	55,400	36.0
E-14	.0358	72	300	78,100	55.0	127,900	61.0	143,300	63.0
E-15	.0357	↕	↕	79,950	56.0	132,900	62.0	147,000	62.0
E-80	.0365	72	300	84,900	59.0	150,000	61.0	156,000	62.0

~SEE PAGE 1-20 FOR NOTES~

CALC	STRICKLAND	4/26/65	REVISED	DATE	ENERGY ABSORBING PROPERTIES 304 ELC 0.114 GAGE SHEET	X-20A
CHECK	[illegible]	4/26/65				D2-80086
APP						
APP					THE BOEING COMPANY	PAGE 1-29

US 4000 0000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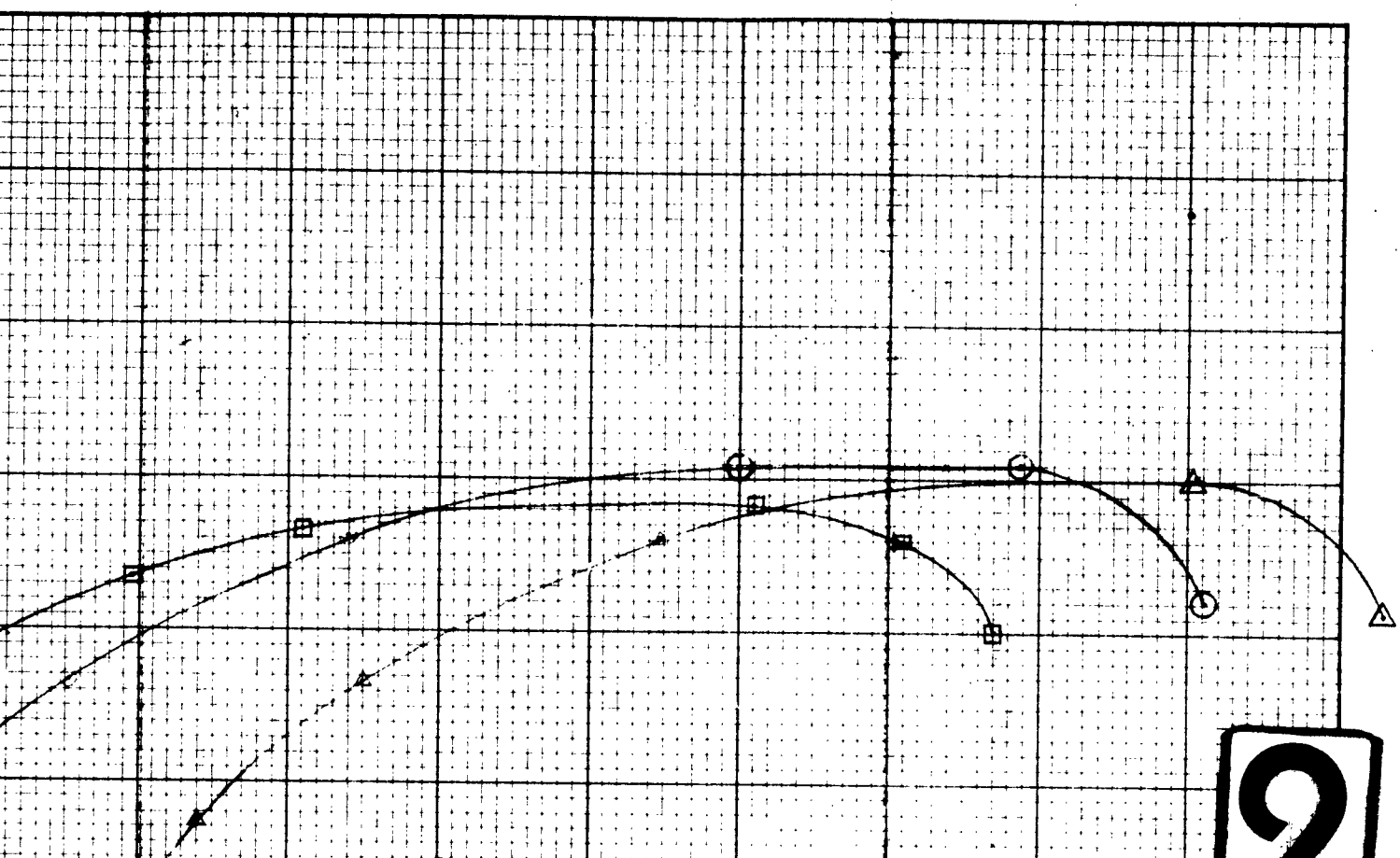

SPEC NO.	ENERGY TO ULT IN-LB/LB	ENERGY TO FAILURE IN-LB/LB	TYPICAL STRAIN IN/IN	TYPICAL STRAIN RATE IN/IN/MIN
AB1	61,400	74,400	(A) = .005	(A) = .001
AB3	70,700	81,600		
AB4	62,300	73,800	(B) = .05	(B) = .10

SPEC NO.	AREA SQ.IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP.°F	TEST ATMOSPHERE
AB2	.0835	58,400	LONG.	+65	NITROGEN
AB3	.0885	60,000	LONG.	+65	NITROGEN
AB4	.0840	60,000	LONG.	+65	NITROGEN

CALC	WAKE	2-21-61	REVISED	DATE	STRESS-STRAIN CURVES NICKEL "A" .109 GAGE SHEET
CHECK	DONNELL	3-6-61			
APR					
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ENGRG	LBD				

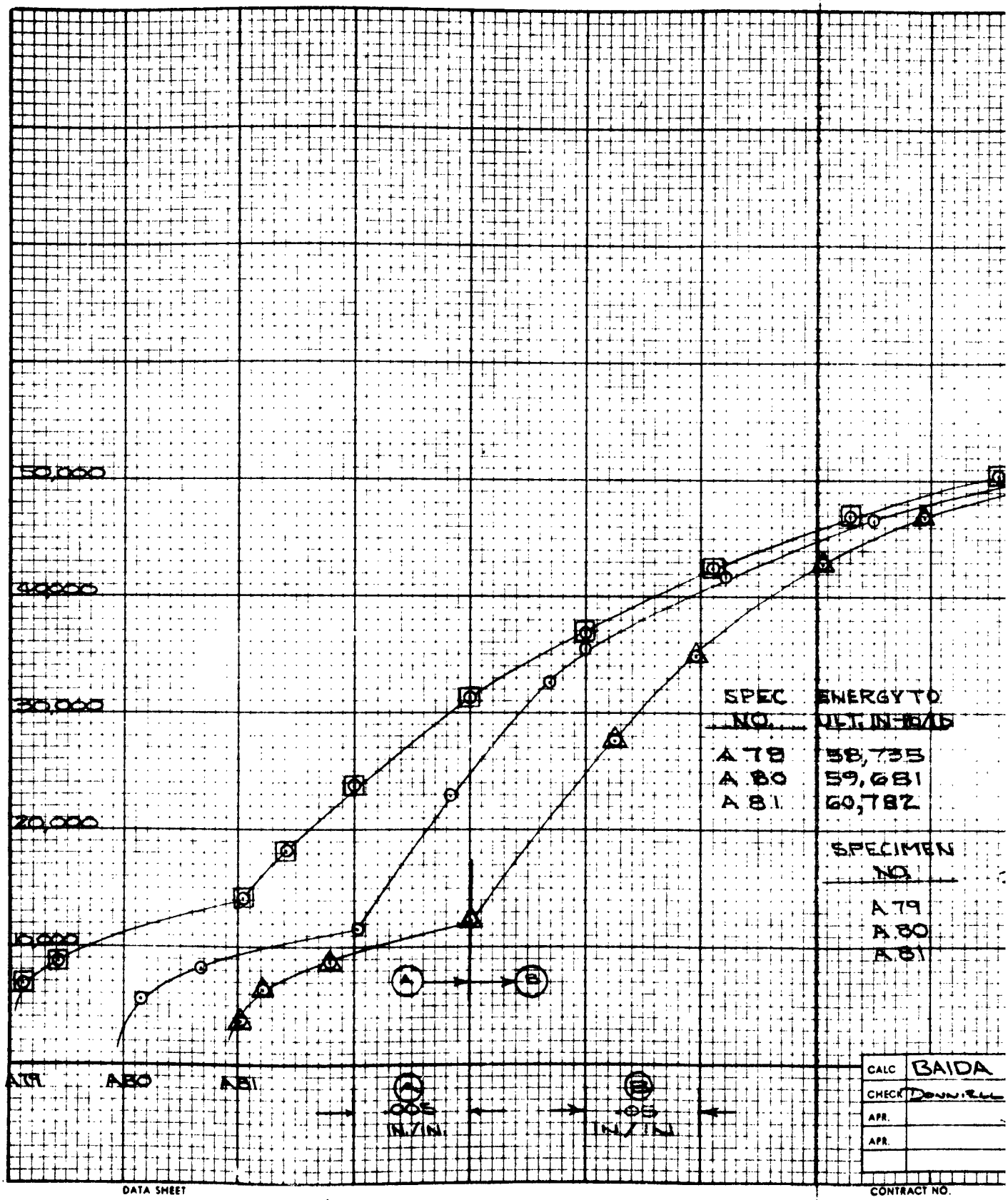
CONTRACT NO

X-20A

D2-80086

BOEING AIRPLANE COMPANY

PAGE 1-30



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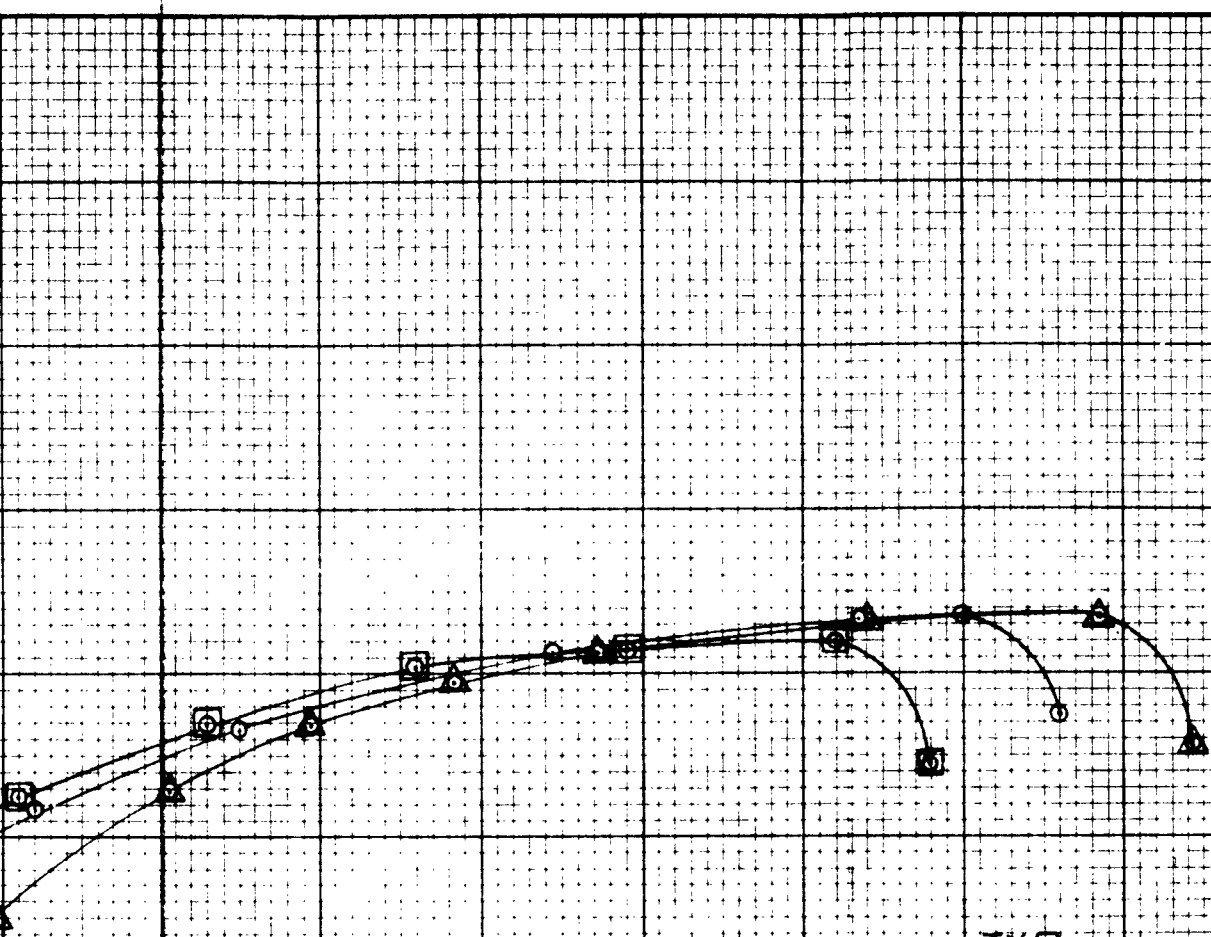
CONTRACT NO.

U3 4011 5000—REV 7/60 (WAS BAC 360D)



2

SPEC NO.	ENERGY TO ULT. IN-LBS/IN²	ENERGY TO FAIL. IN-LBS/IN²	TYP. STRAIN ≈ IN./IN.	TYP. STRAIN RATE ≈ IN./IN./MIN
A 79	58,735	63,235	(A) ±.005	(A) ±.005
A 80	59,681	64,125		
A 81	60,782	65,362	(B) ±.05	(B) ±.10

SPECIMEN NO.	AREA ±SQ. IN.	FTU ≈ PSI	GRAIN DIRECT	TEST TEMP (°F)	TEST ATMOS.
A 79	.0535	52,000	LONG.	72	AIR
A 80	.0545	53,500	LONG.	72	AIR
A 81	.0542	55,500	LONG.	72	AIR

			REVISED	DATE
CALC	BAIDA	1-14-61		
CHECK	DONNELL	1-14-61		
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CONTRACT NO.

STRESS – STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

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BOEING AIRPLANE COMPANY

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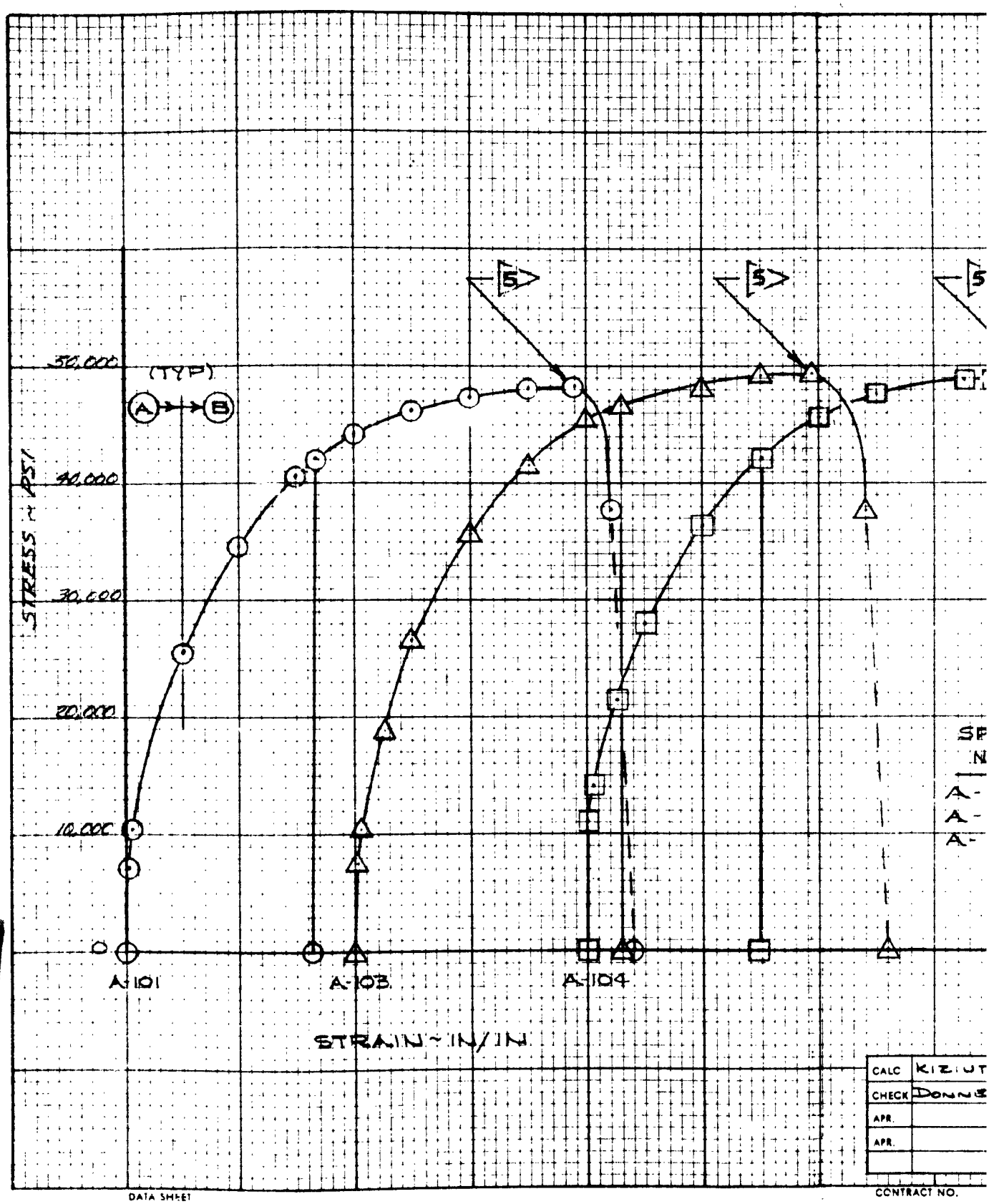

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CONTRACT NO.

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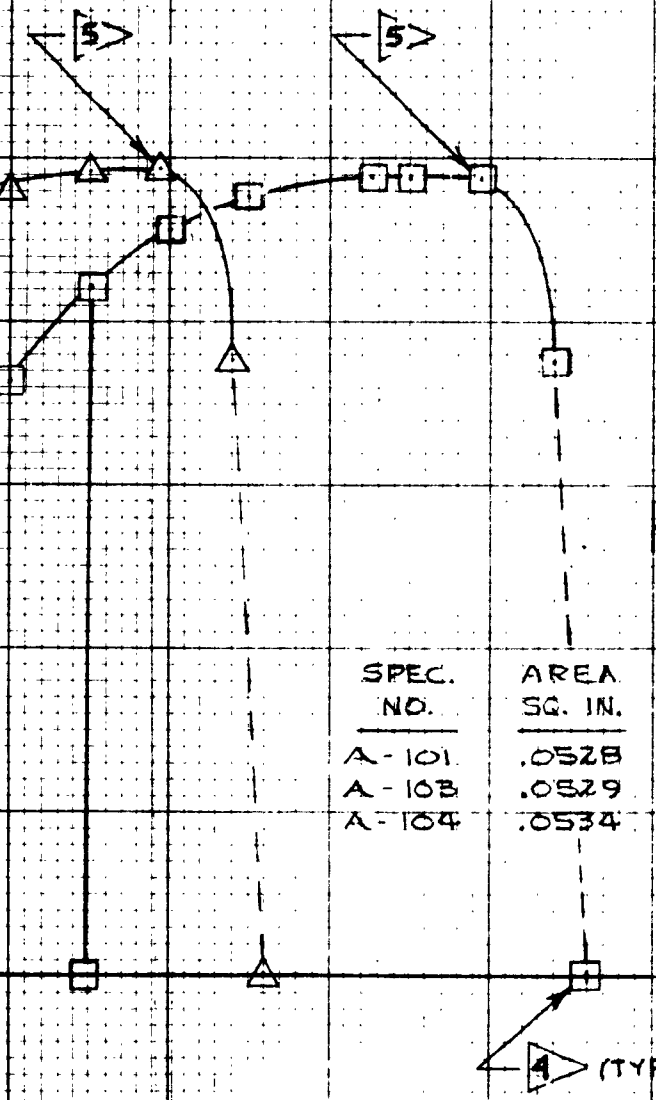

SPEC. NO.	ENERGY TO FTU IN-LB./LB.	ENERGY TO FAILURE IN.-LB./LB.
A-101	47,500	53,250
A-103	50,200	57,400
A-104	49,900	57,800

STRAIN IN./IN. ←.10→

STRAIN RATE IN./IN./MIN.

(A) = .005

(B) = .05

2

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
A-101	.0528	48,300	LONG.	R.T.	AIR
A-103	.0529	49,300	LONG.	R.T.	AIR
A-104	.0534	48,500	LONG.	R.T.	AIR

SEE PAGE 1.20 FOR NOTES

CALC	KIZ. UTA.	5-4-1	REVISED	DATE	STRESS STRAIN CURVES NICKEL "A" .109 GAGE SHEET
CHECK	DONNELL	5-8-1			
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BOEING AIRPLANE COMPANY

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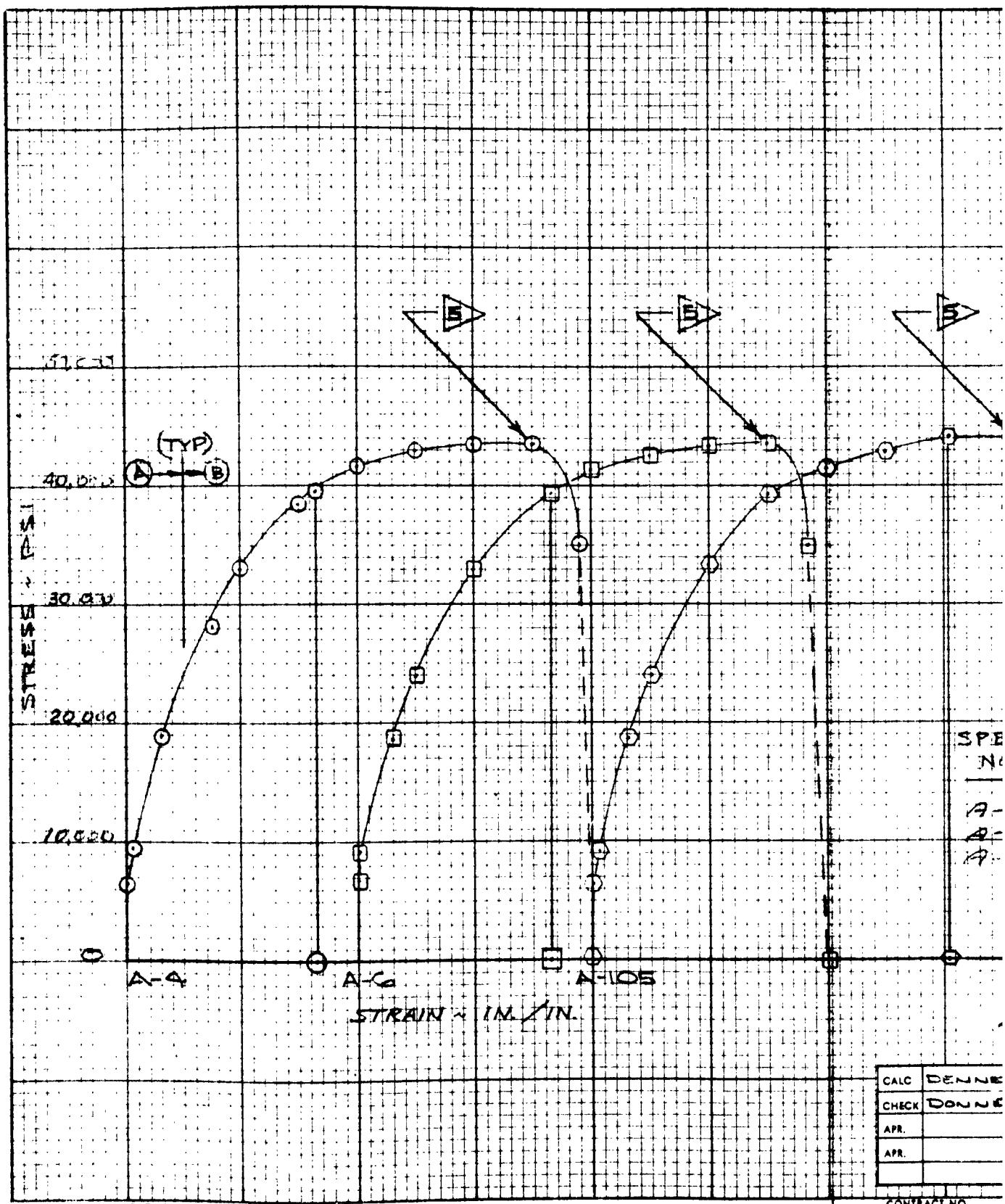
CONTRACT NO.



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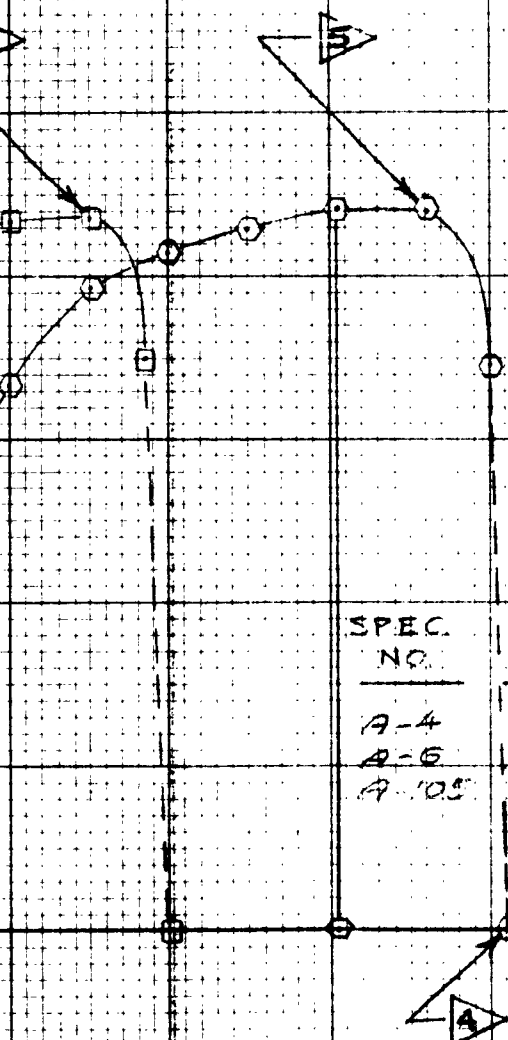
CONTRACT NO.

U3 4011 5000—REV 1/60 (WAS BAC 3600)



SPEC. NO.	ENERGY TO FTU IN-LB./LB.	ENERGY TO FAILURE IN-LB./LB.
A-4	38,800	44,700
A-6	38,900	44,200
A-105	40,500	46,200

STRAIN IN./IN.	STRAIN RATE IN./IN./MIN.
.10	(A) =.005
	(B) =.05

2

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP.~°F	TEST ATMOS.
A-4	.0529	43,700	LONG.	600	AIR
A-6	.0542	43,500	LONG.	600	AIR
A-105	.0533	44,100	LONG.	600	AIR

SEE PAGE 1-20 FOR NOTES

			REVISED	DATE	STRESS STRAIN CURVES NICKEL "A" .109 GAGE SHEET	X-20A
CALC	DENNEY	5-4-1				D2-8008G
CHECK	DONNELL	5-8-1				
APR.					BOEING AIRPLANE COMPANY	PAGE 1-33
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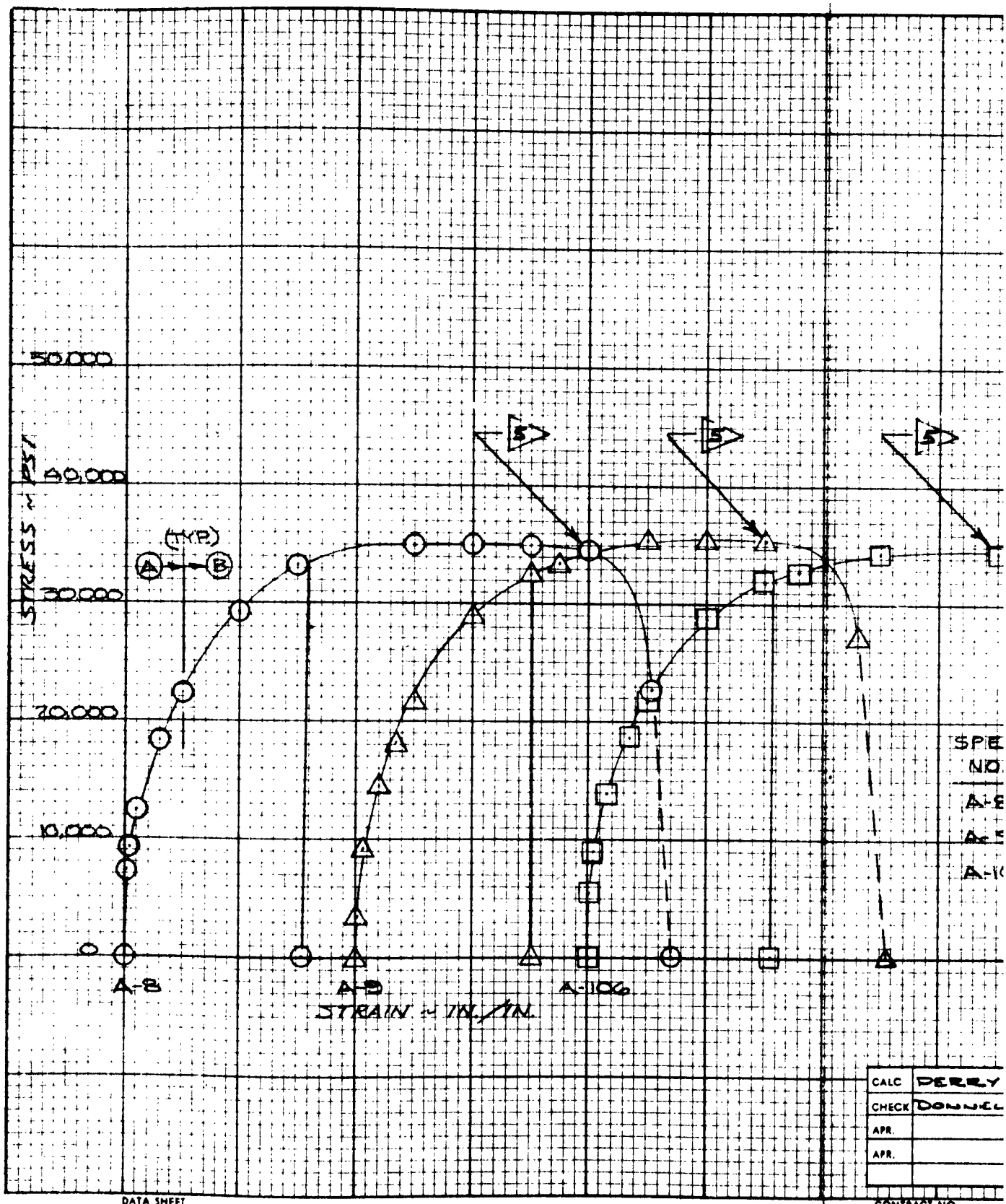
CONTRACT NO



DATA SHEET

CONTRACT NO.

U3 4011 5008—REV 7/60 (WAS BAC 360D)

SPEC. NO.	ENERGY TO FTU IN-LB./LB.	ENERGY TO FAILURE IN.-LB./LB.
A-2B	35,200	44,400
A-5	32,600	42,200
A-106	32,100	40,100

STRAIN IN./IN.	STRAIN RATE IN./IN./MIN.
.10	(A) = .005 (B) = .05

2

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-2B	.0593	35,000	LONG.	800	AIR
A-5	.0551	35,500	LONG.	800	AIR
A-106	.0539	34,500	LONG.	800	AIR

SEE PAGE 1-40 FOR NOTES

			REVISED	DATE
CALC	PERRY	5-5-1		
CHECK	DONNELL	5-8-1		
APR.				
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STRESS STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

BOEING AIRPLANE COMPANY

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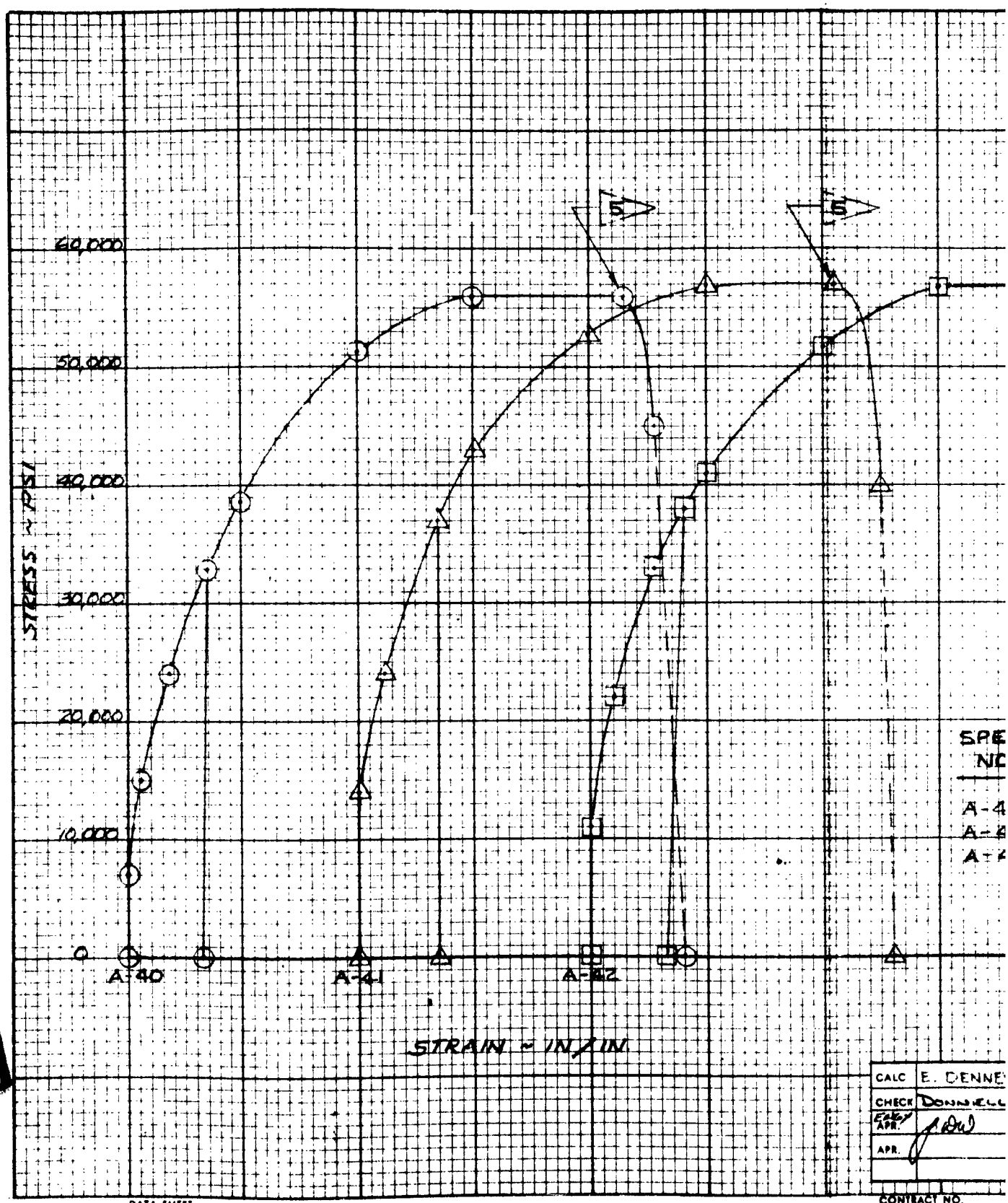
PAGE 1-34

CONTRACT NO.



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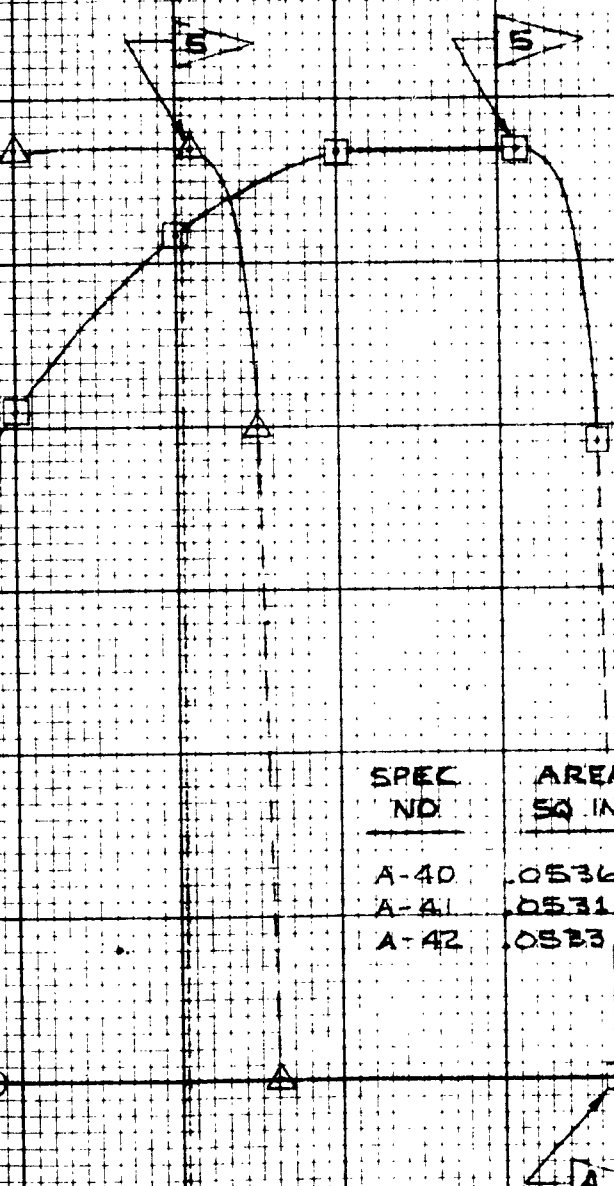

SPEC NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-40	61,700	67,800
A-41	60,500	68,500
A-42	60,000	69,000

STRAIN IN/IN	STRAIN-RATE IN/IN/MIN
.10	50

SPEC NO.	AREA SQ IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-40	.0536	54,000	LONG.	72	AIR
A-41	.0531	57,000	LONG.	72	AIR
A-42	.0533	57,000	LONG.	72	AIR

SEE PAGE 120 FOR NOTES

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CALC	E. DENNEY	5/16/61	REVISED	DATE	STRESS-STRAIN CURVES NICKEL "A" .109 GAGE SHEET
CHECK	DONNELL	5/16/61			
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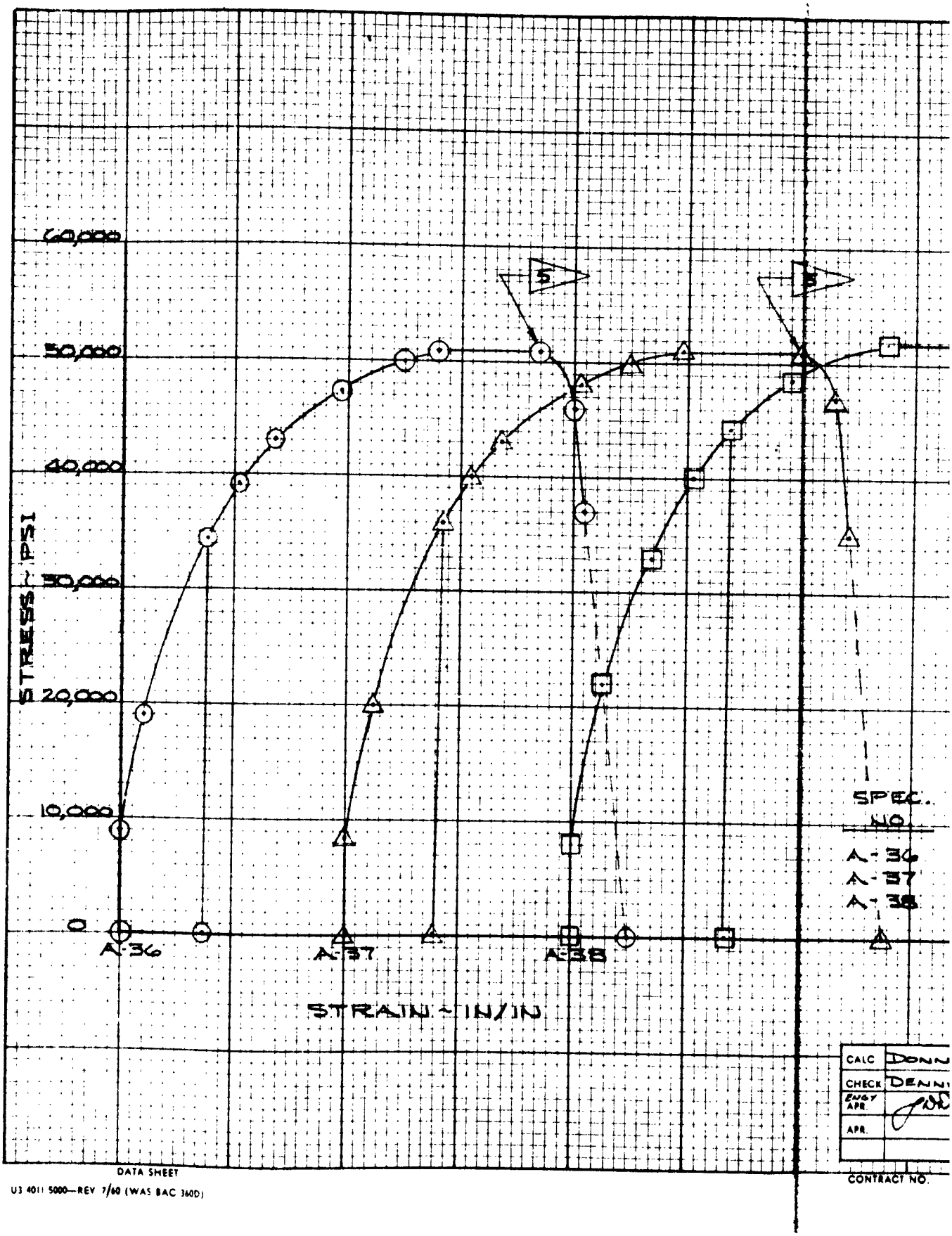
CONTRACT NO.



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ENGR APR.	
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CONTRACT NO.

U3 4011 5000—REV 7/60 (WAS BAC 360D)

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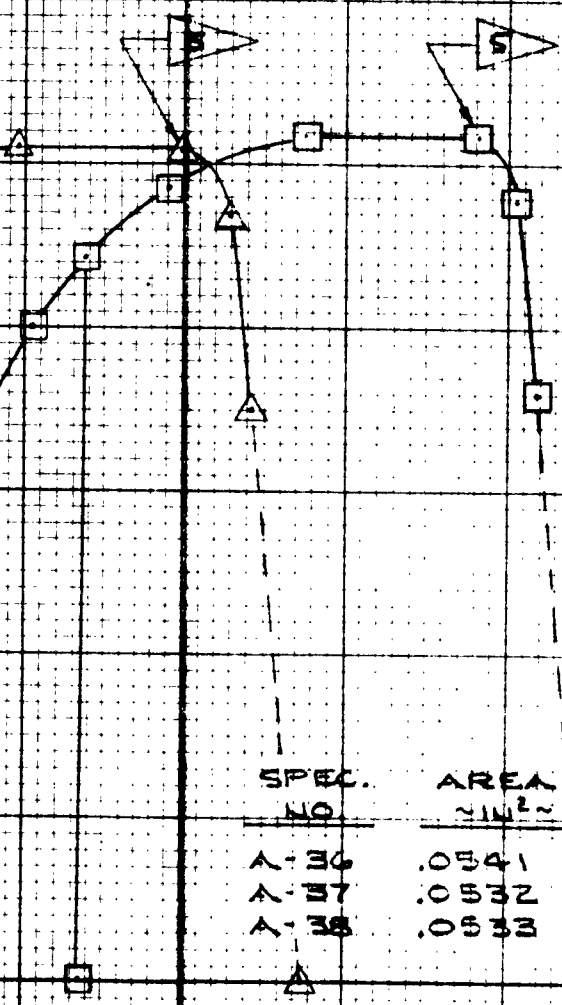

SPEC. NO.	ENERGY TO FTU. ~IN-LB/LB.~	ENERGY TO FAILURE ~IN-LB/LB.~
A-36	48,500	56,700
A-37	53,000	61,200
A-38	51,200	58,500

STRAIN ~IN/IN.~	STRAIN-RATE ~IN/IN/MIN.~
.10	50

SPEC. NO.	AREA ~IN²~	FTU. ~PSI.~	GRAIN DIRECTION	TEST TEMP. ~°F.~	TEST ~ATMOS.~
A-36	.0541	51,000	LONG.	250	AIR
A-37	.0532	51,000	LONG.	250	AIR
A-38	.0533	51,900	LONG.	250	AIR

SEE PAGE 140 FOR NOTES

			REVISED	DATE
CALC	DONNELL	5-12-1		
CHECK	DENNEY	5-12-1		
ENGR APR				
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STRESS-STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

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BOEING AIRPLANE COMPANY

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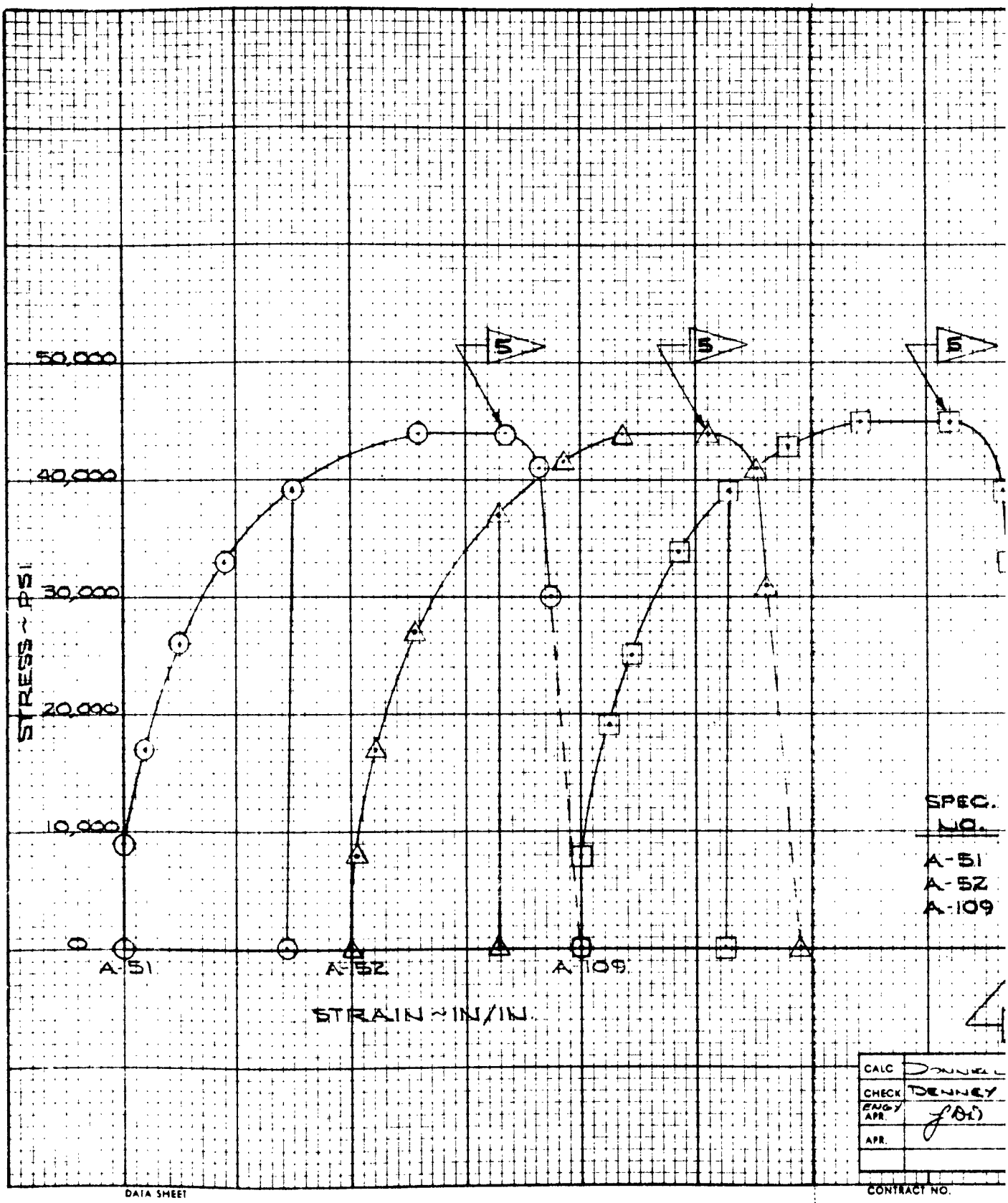
CONTRACT NO.



U3 4011 5800—REV 7/60 (WAS BAC 3600)

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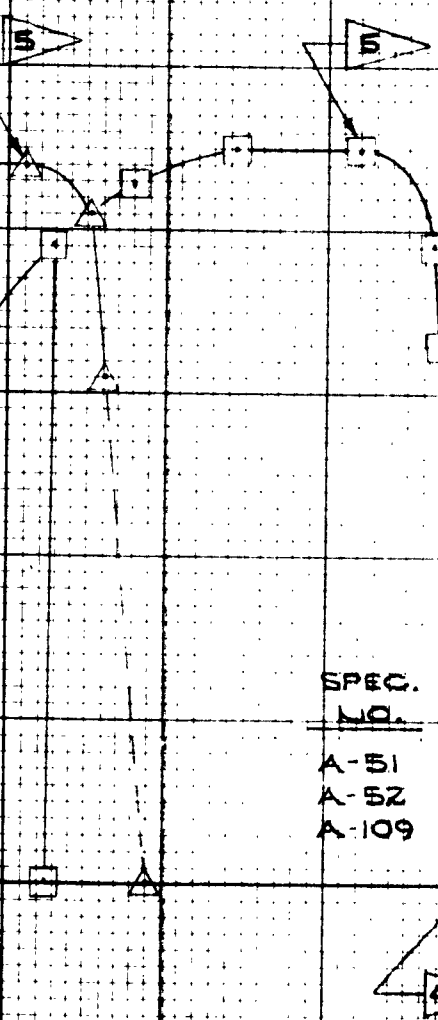

SPEC. NO.	ENERGY TO FTU. ~IN-LBS/LB~	ENERGY TO FAILURE ~IN-LB/LB.~
A-51	38,000	44,200
A-52	34,300	42,300
A-109	37,100	44,700

STRAIN ~IN/IN~	STRAIN-RATE ~IN/IN/MIN.~
.10	50

SPEC. NO.	AREA ~IN^2~	FTU ~PSI~	GRAIN DIRECTION	TEST TEMP ~°F~	TEST ATMOS.
A-51	.0532	44,000	LONG.	600	AIR
A-52	.0534	44,000	LONG.	600	AIR
A-109	.0539	46,000	LONG.	600	AIR

SEE PAGE 40 FOR NOTES

CALC	DONNA J. 5-15-61	REVISED	DATE	STRESS — STRAIN CURVES NICKEL "A" .109 GAGE SHEET	X-20A
CHECK	DENNEY 5-15-61				D2-8008
ENGR APR	JDD			BOEING AIRPLANE COMPANY	37
APR.					

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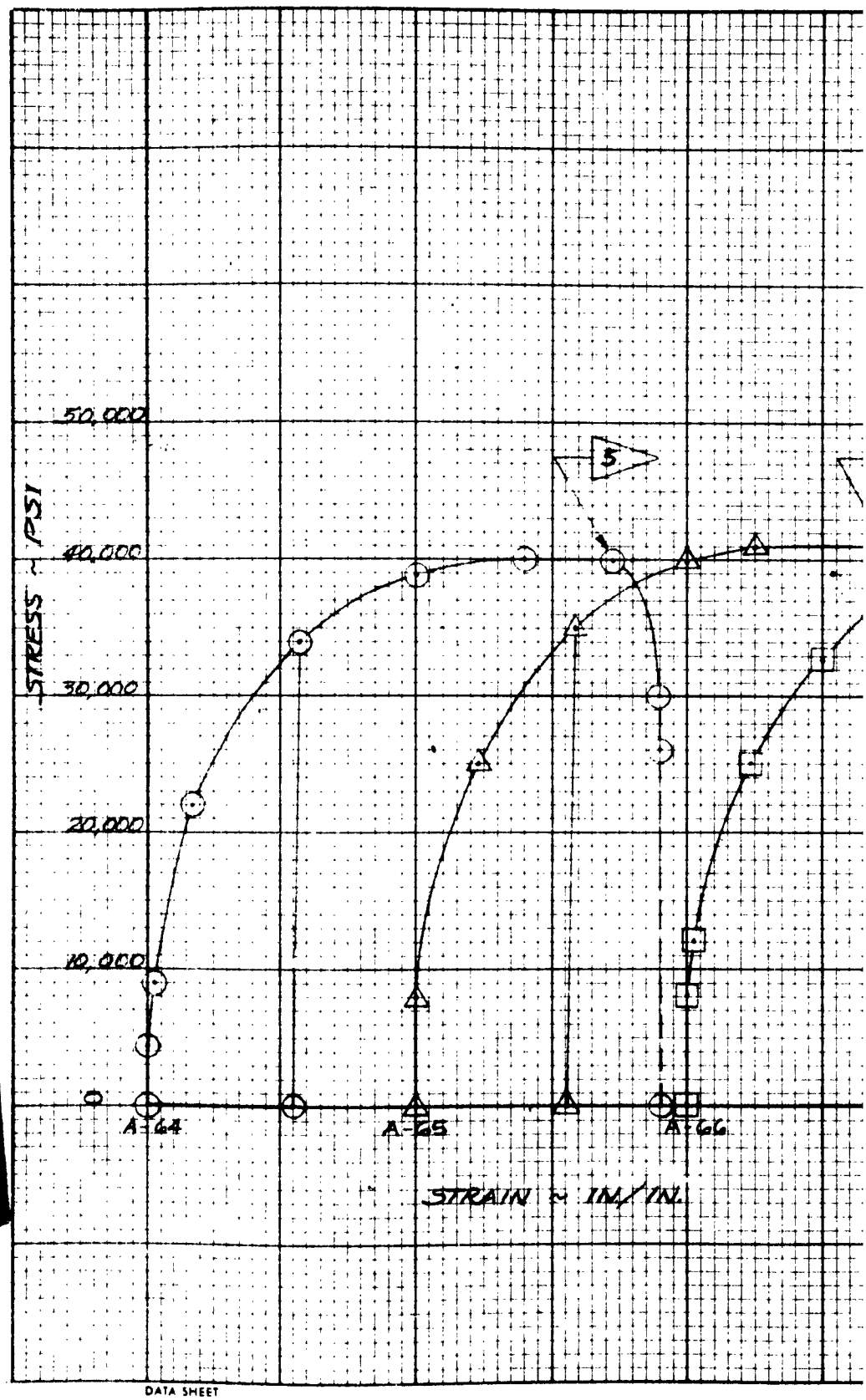
50,000
40,000
30,000
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10,000
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STRESS - PSI
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A-64
A-65
A-66
STRAIN ~ IN./IN.

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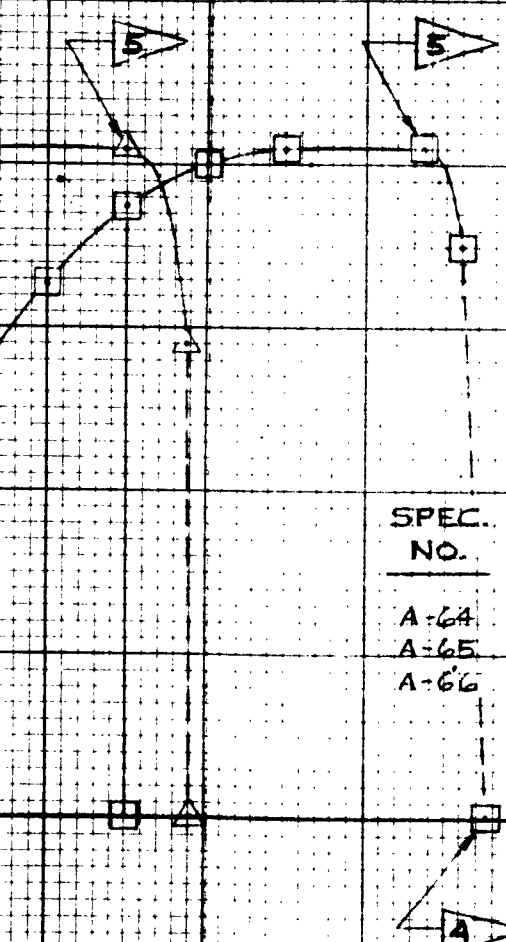

SPEC. NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-64	36,200	40,400
A-65	38,100	42,200
A-66	36,000	39,400

STRAIN IN/IN	STRAIN-RATE IN/IN/MIN
.10	50

2

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
A-64	.0527	40,000	LONG.	800	AIR
A-65	.0527	41,000	LONG.	800	AIR
A-66	.0535	41,000	LONG.	800	AIR

SEE PAGE 1-40 FOR NOTES

			REVISED	DATE
CALC	E. DENNEY	5/16/61		
CHECK	DONIELL	5-16-1		
ENGR APR	[illegible]			
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CONTRACT NO.

STRESS-STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

BOEING AIRPLANE COMPANY

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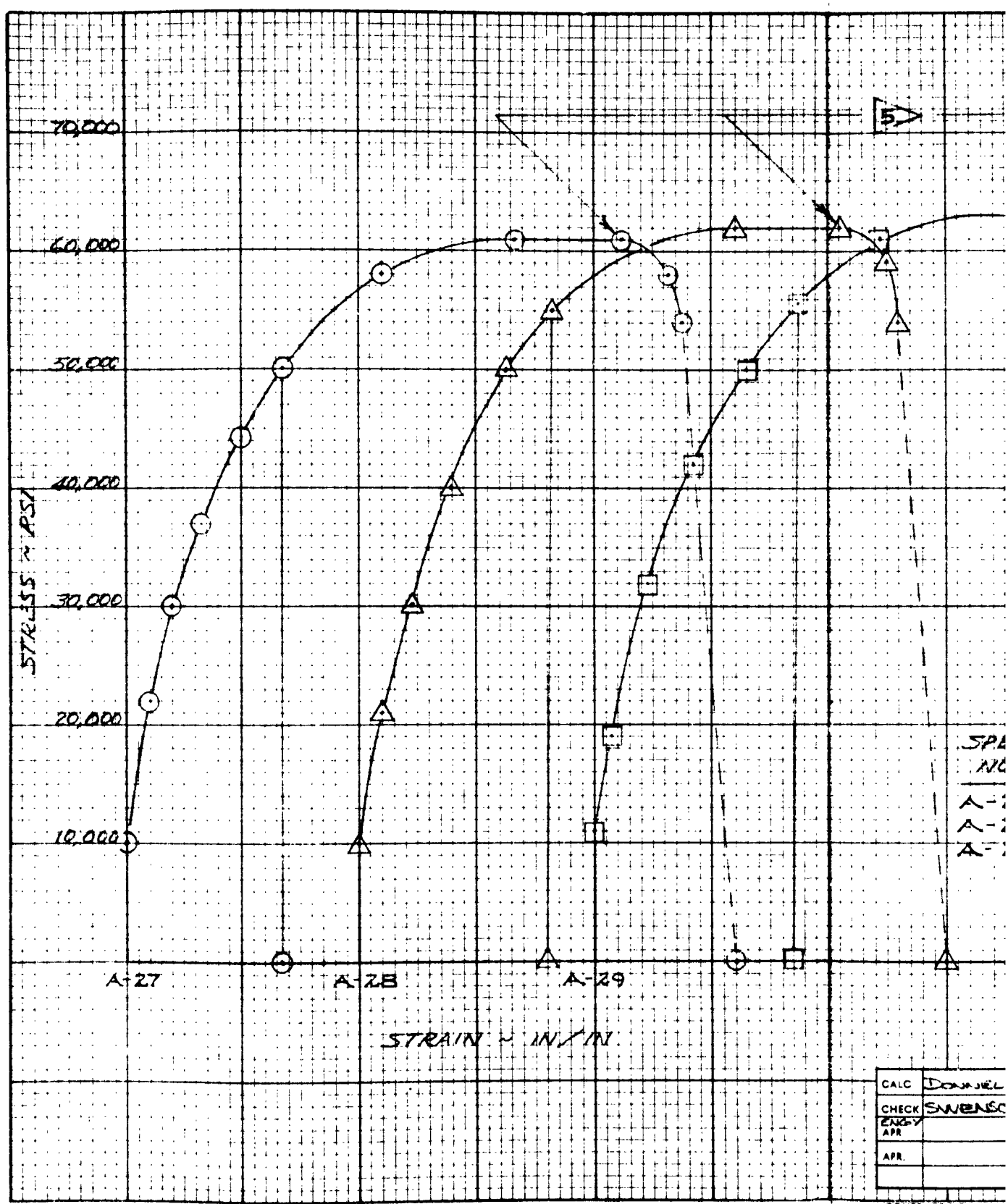

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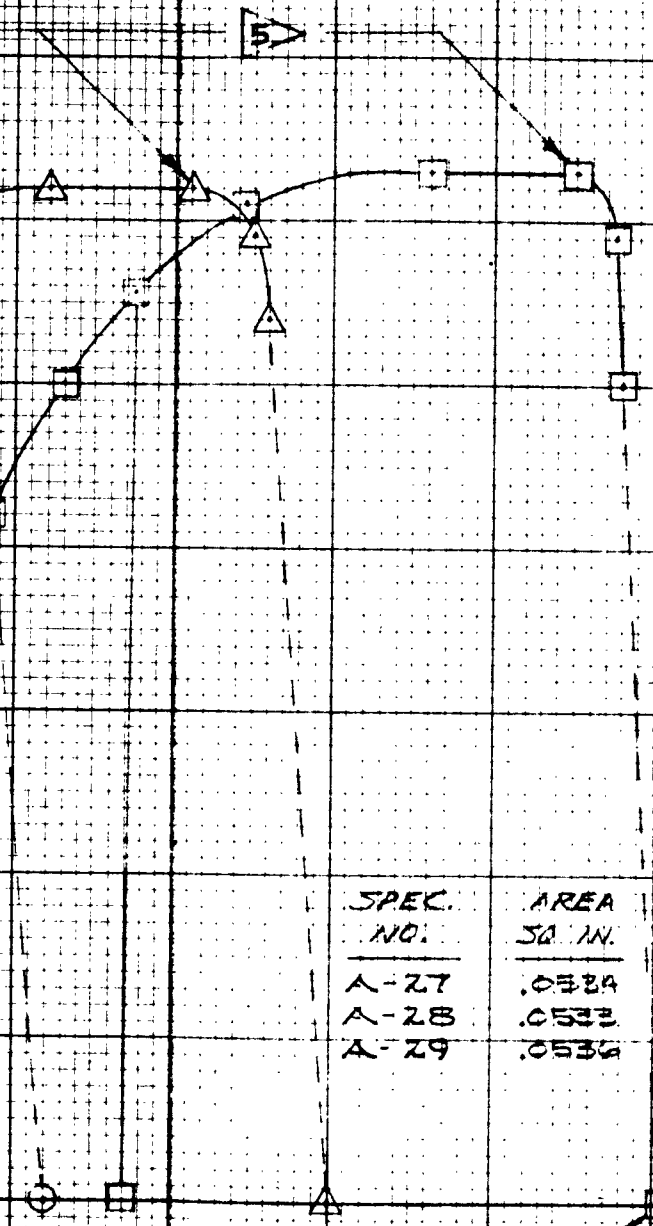
CONTRACT NO.



SPEC. NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-27	68,100	80,800
A-28	66,000	78,900
A-29	73,900	82,000

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	50

SPEC. NO.	AREA SQ IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-27	.0328	61,000	LONG	-65	NITROGEN
A-28	.0532	62,000	LONG	-65	NITROGEN
A-29	.0536	62,000	LONG	-65	NITROGEN

SEE PAGE 1-20 FOR NOTES

2

			REVISED	DATE
CALC	DONNELL	5-19-1		
CHECK	SWENSON	5-19-1		
ENGR APR				
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STRESS STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

X-20A

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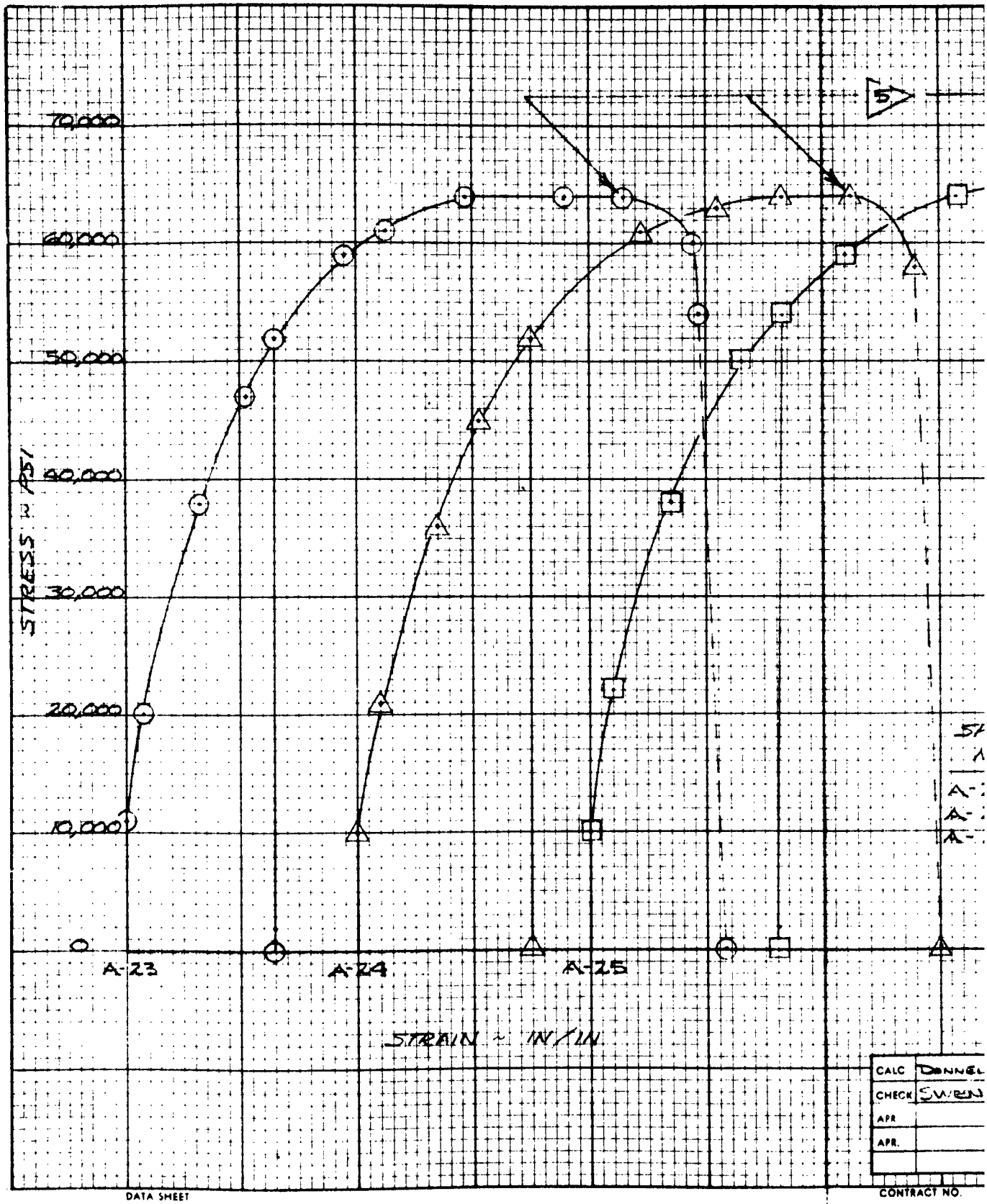
BOEING AIRPLANE COMPANY

PAGE 1-40

CONTRACT NO.



CALC DONNEL
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DATA SHEET

CONTRACT NO.

UJ 4011 5000—REV 7/60 (WAS BAC 360D)

SPEC NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-23	72,300	86,400
A-24	69,000	81,400
A-25	73,100	85,200

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	100

SPEC. NO.	AREA SQ IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-23	.0533	64,000	LONG	-65	NITROGEN
A-24	.0534	64,000	LONG	-65	NITROGEN
A-25	.0534	65,000	LONG	-65	NITROGEN

SEE PAGE 1-2B FOR NOTES

2

CALC	DONNELL	5-19-1	REVISED	DATE	STRESS STRAIN CURVES NICKLE A .109 GAGE SHEET
CHECK	SWENSON	5-19-1			
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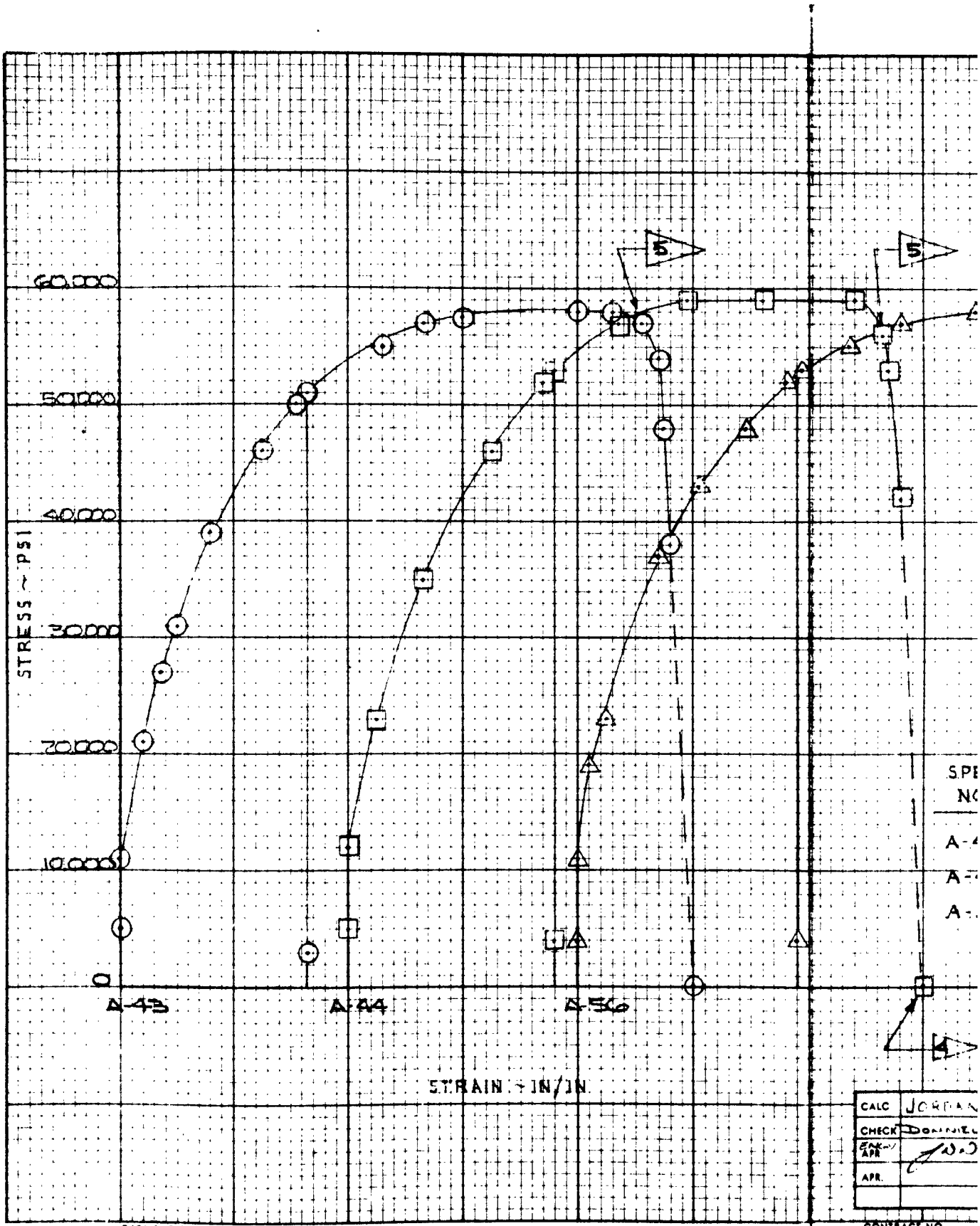
BOEING AIRPLANE COMPANY

CONTRACT NO.



DATA SHEET

CONTRACT NO.

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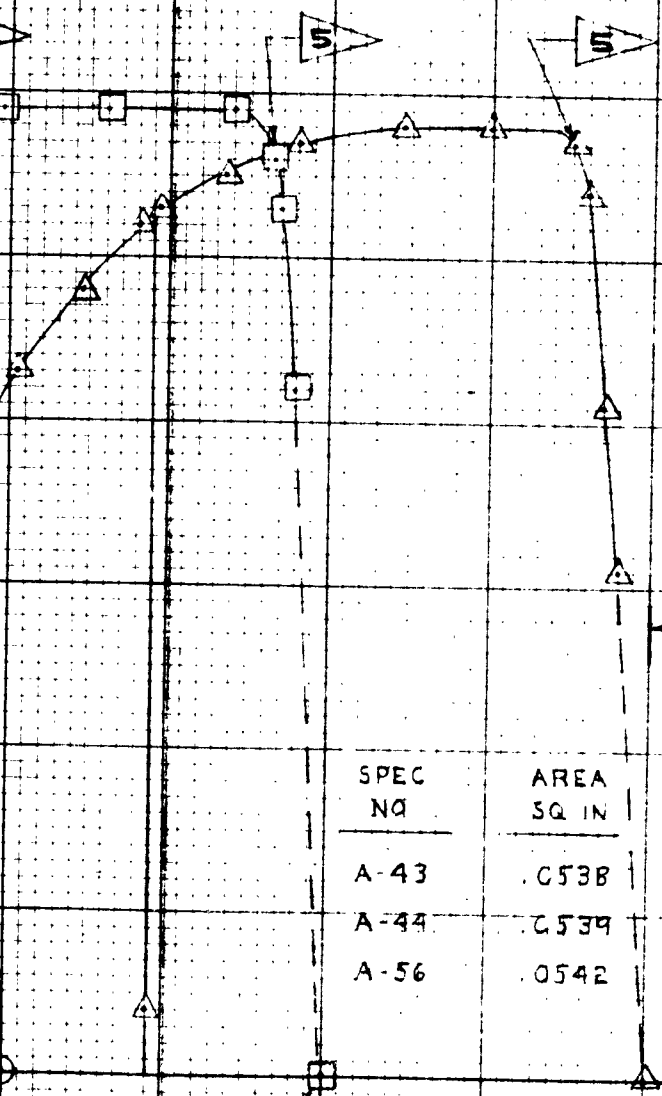

SPEC NO	ENERGY TO FTU IN-LB / LB	ENERGY TO FAIL IN-LB / LB
A-43	70,300	75,400
A-44	72,700	76,400
A-56	69,100	74,500

STRAIN IN/IN	STRAIN RATE IN./IN / MIN.
.10	100

SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-43	.0538	58,000	LONG.	72	AIR
A-44	.0539	59,000	LONG.	72	AIR
A-56	.0542	58,000	LONG.	72	AIR

SEE PAGE 1-20 FOR NOTES

			REVISED	DATE
CALC	JOHNSON	5-17-61		
CHECK	DOUGLAS	5-17-61		
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STRESS-STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

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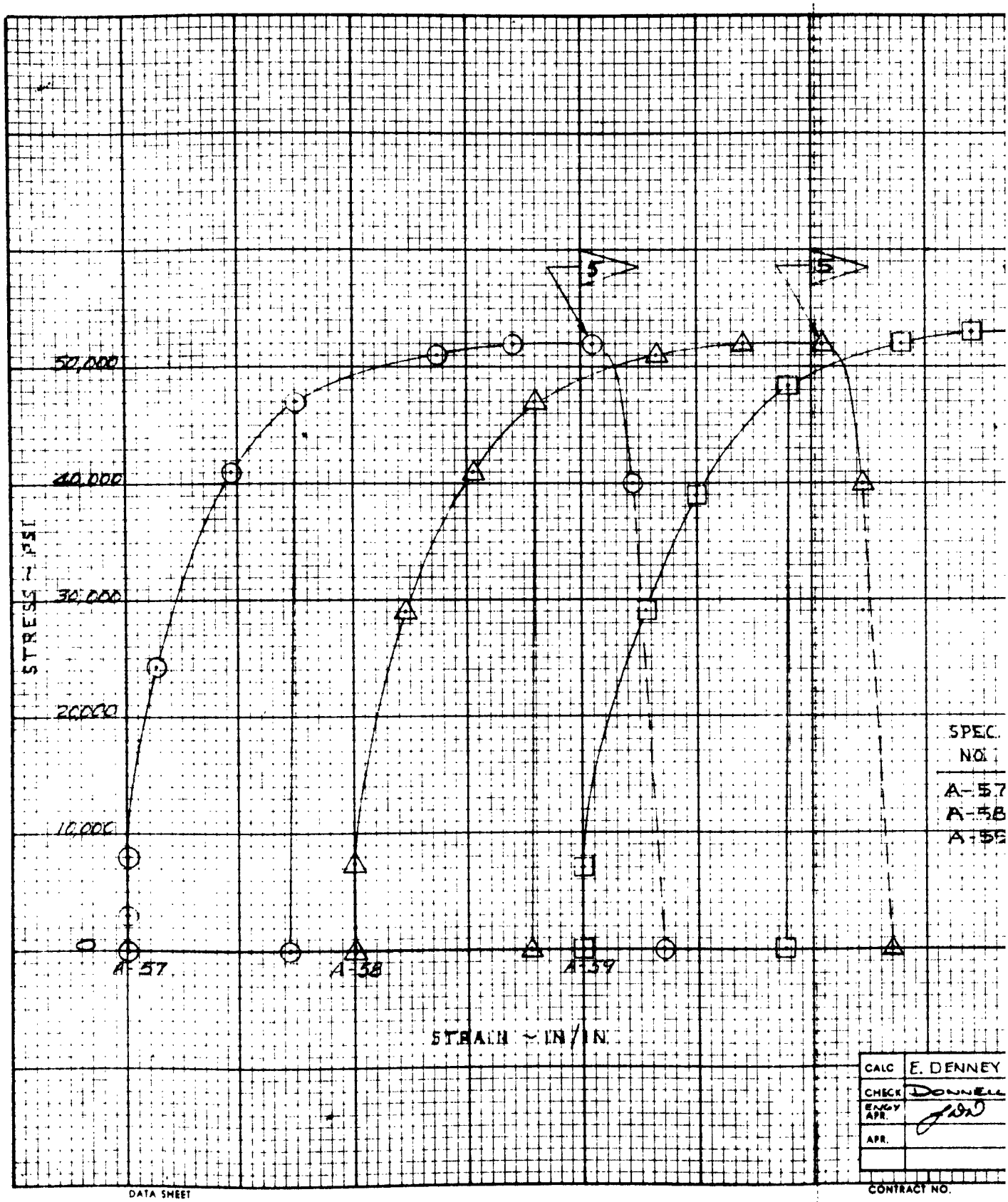
BOEING AIRPLANE COMPANY

CONTRACT NO.



CALC	E. DENNEY
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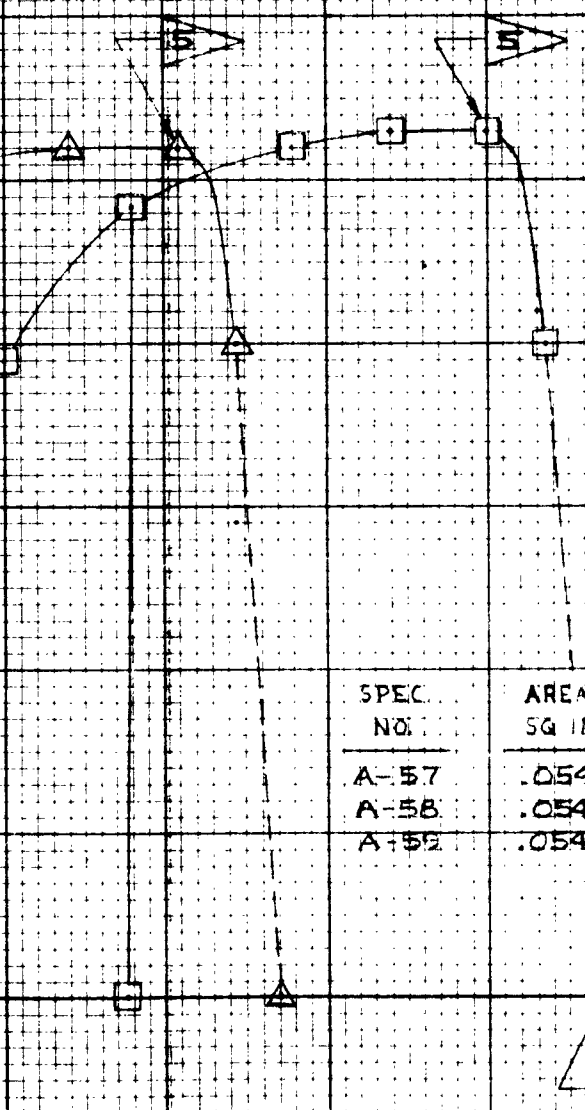
CONTRACT NO.



SPEC NO	ENERGY TO FTU IN-LB / LB	ENERGY TO FAIL IN-LB / LB
A-57	57,300	64,000
A-58	56,400	63,100
A-59	55,000	62,400

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	100

2

SPEC NO.	AREA SQ IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-57	.0541	52,000	LONG.	250	AIR
A-58	.0545	52,000	LONG.	250	AIR
A-59	.0543	53,000	LONG.	250	AIR

SEE PAGE 1-20 FOR NOTES

			REVISED	DATE
CALC	E. DENNEY	5/17/61		
CHECK	DONNELL	5-17-1		
ENGR APR.				
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CONTRACT NO.

STRESS-STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

BOEING AIRPLANE COMPANY

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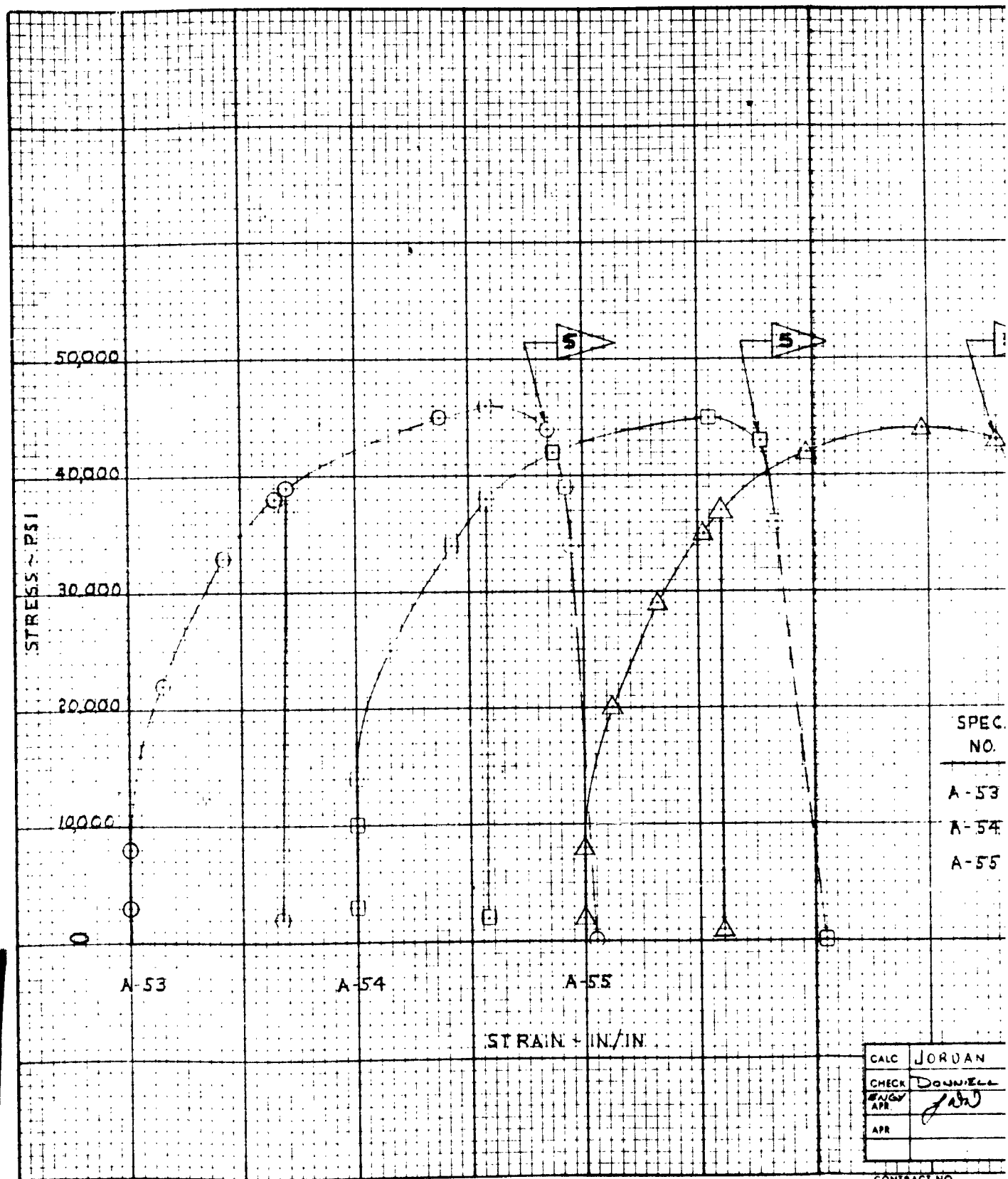

SPEC. NO.

A-53

A-54

A-55

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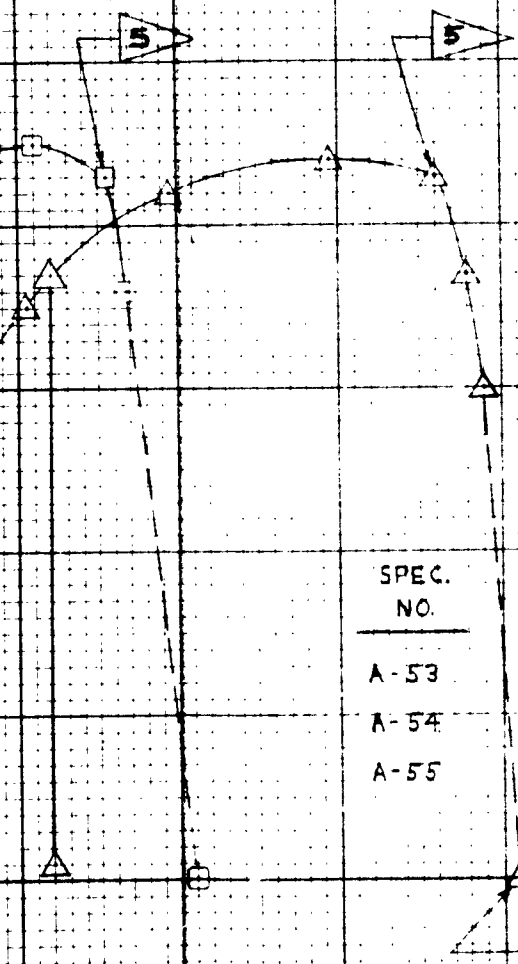
CONTRACT NO.

DATA SHEET

U3 4011 5000—REV 7/60 (WAS BAC 360D)



SPEC. NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-53	43,900	47,300
A-54	42,900	46,500
A-55	41,600	46,000

STRAIN IN/IN	STRAIN RATE IN/IN/MIN.
.10	100

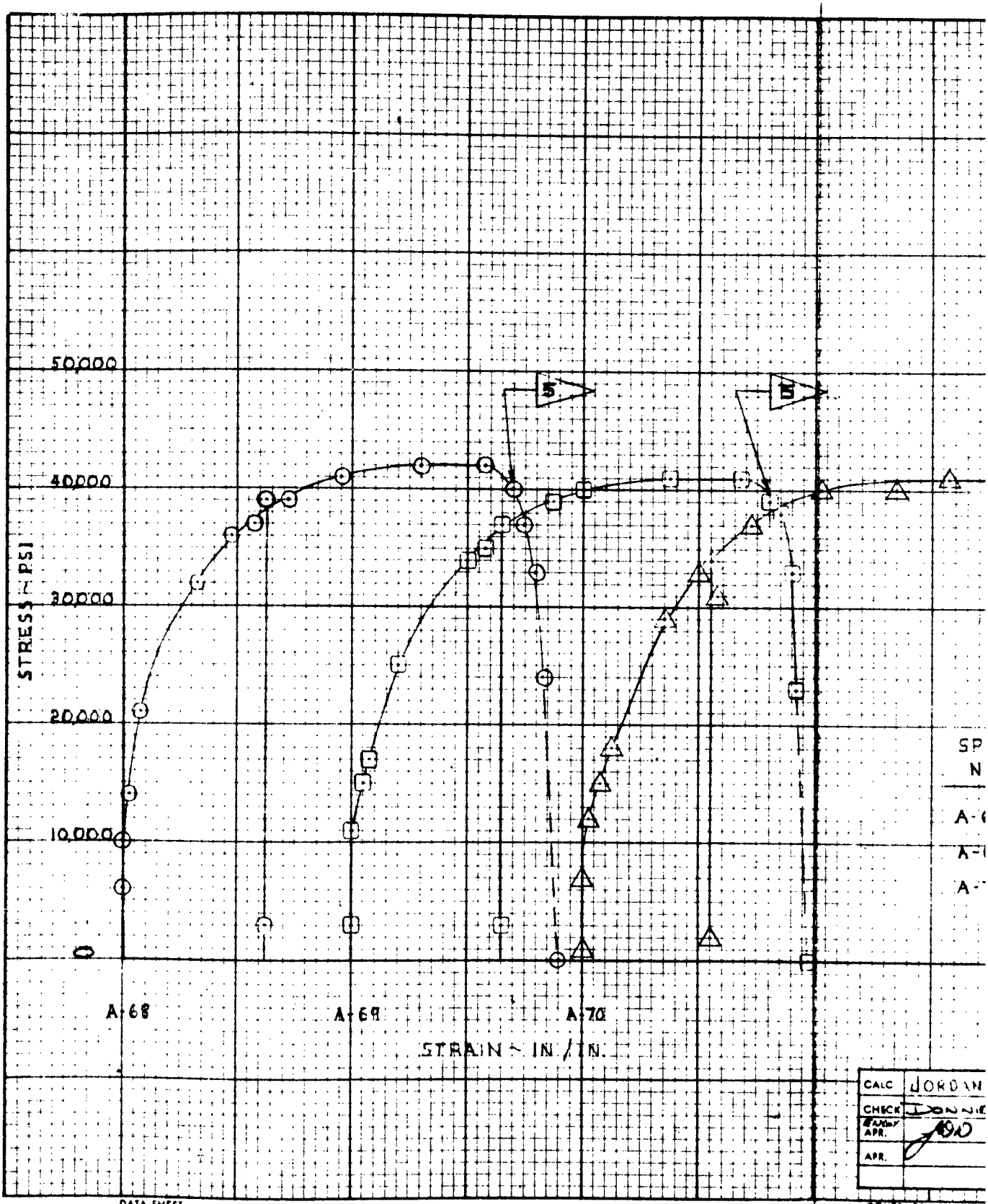
SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
A-53	.0532	46,000	LONG	600	AIR
A-54	.0536	45,000	LONG	600	AIR
A-55	.0539	44,000	LONG	600	AIR

SEE PAGE I-20 FOR NOTES

			REVISED	DATE
CALC	JORDAN	5-16-61		
CHECK	DONNELL	5-16-61		
STRESS APR				
APR				

STRESS-STRAIN CURVES X-20A
NICKEL A
.109 GAGE SHEET D2-80086
BOEING AIRPLANE COMPANY PAG. I-44

CONTRACT NO.



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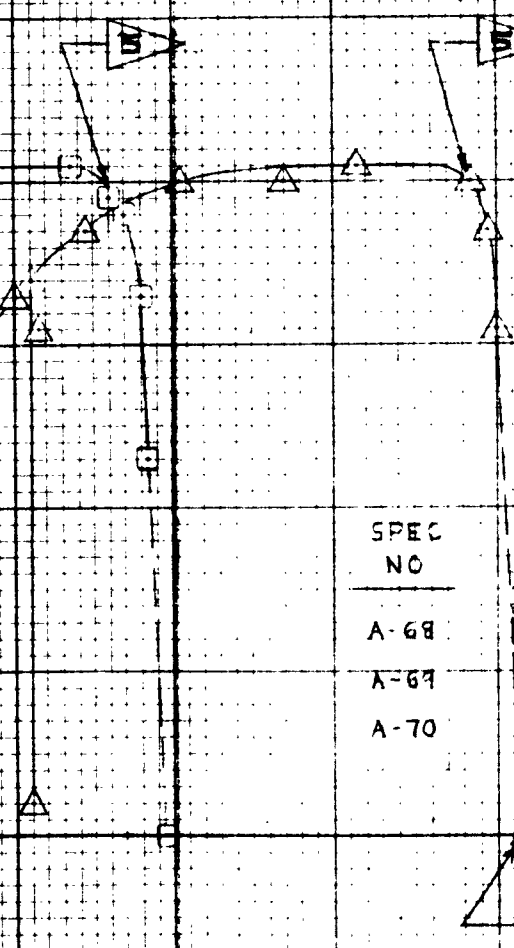
CALC	JORDAN
CHECK	JONNIE
APR.	
APR.	

DATA SHEET

CONTRACT NO.

U3 4011 5008—REV 7/60 (WAS BAC 360D)



SPEC NO	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-68	39,200	42,400
A-69	39,800	42,900
A-70	42,300	44,800

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	100

SPEC NO	AREA SQ IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-68	.0539	42,000	LONG	800	AIR
A-69	.0544	41,000	LONG	800	AIR
A-70	.0545	41,000	LONG	800	AIR

(TYP)

SEE PAGE 1-20 FOR NOTES

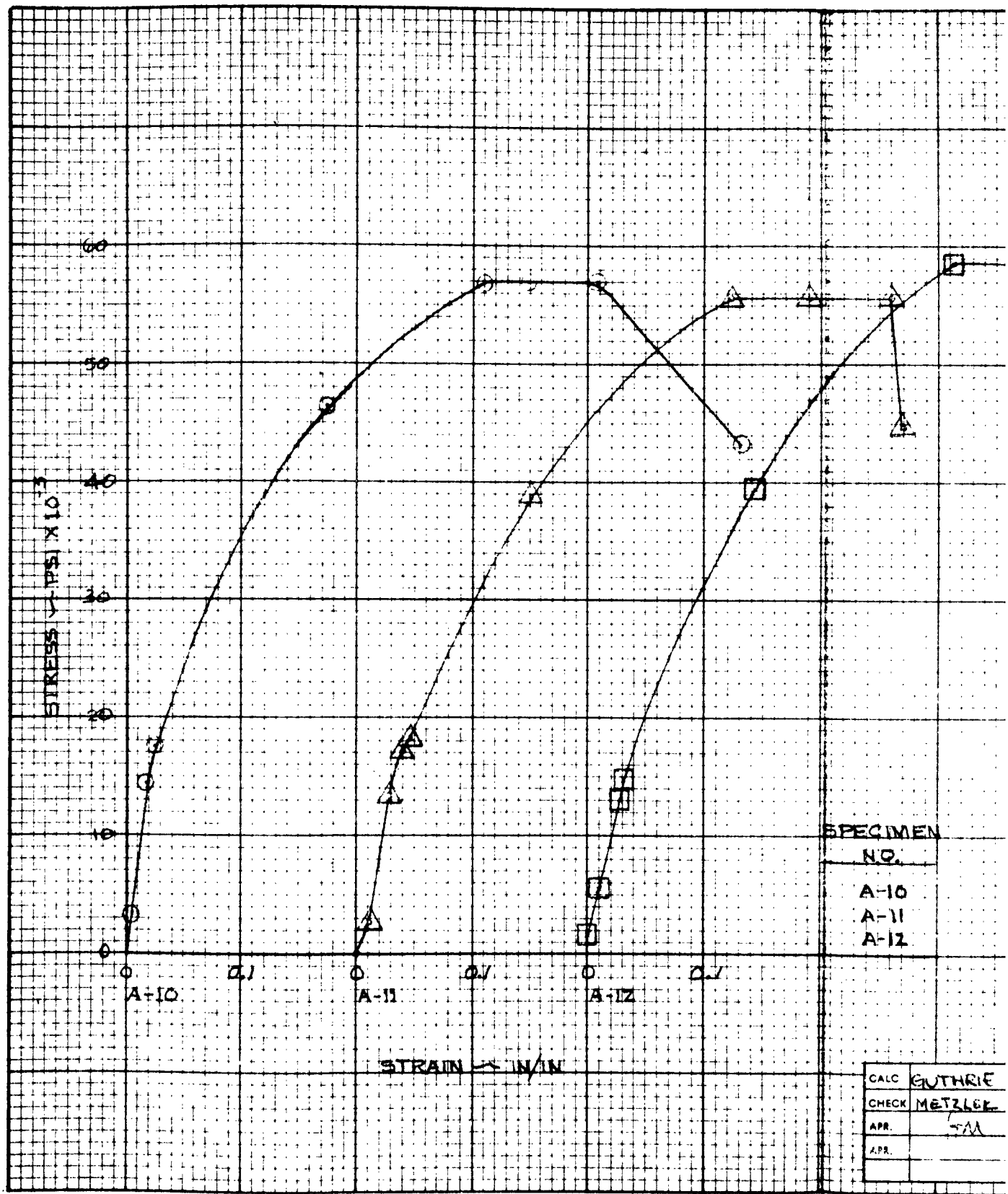
CALC	JORDAN	5-16-61	REVISED	DATE
CHECK	JONNEAU	5-17-61		
STRESS APP.	[illegible]			
APP.				

STRESS-STRAIN CURVES
NICKEL A
.109 GAGE SHEET

X-20A
D2-80006

BOEING AIRPLANE COMPANY

CONTRACT NO

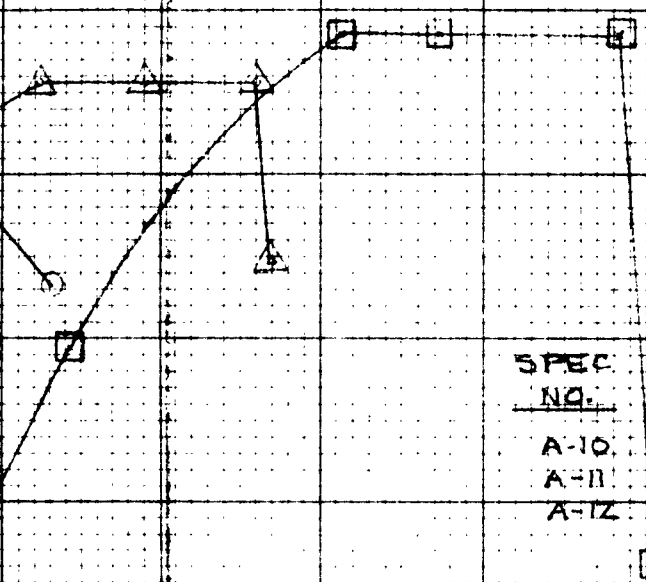


CALC	GUTHRIE
CHECK	METZLER
APP.	
APP.	

DATA SHEET

CONTRACT NO.

U3 4011 5000—REV 7/60 (WAS BAC 3600)



SPEC. NO.	ENERGY TO ULT. IN-lb/lb	ENERGY TO FAIL. IN-lb/lb
A-10	56,100	74,900
A-11	60,500	62,100
A-12	68,600	71,100

STRAIN ε IN/IN

← 0.1 →

STRAIN RATE $\dot{\varepsilon}$ IN/IN/MIN

180 (TYP)

2

SPECIMEN NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP (°F)	TEST ATMOS.
A-10	.0549	57,000	LONG.	72	AIR
A-11	.0549	55,700	LONG.	72	AIR
A-12	.0538	58,600	LONG.	72	AIR

			REVISED	DATE
CALC	GUTHRIE	1-27-61		
CHECK	METZLER	1-27-61		
APR.		1-29-61		
APR.				

STRESS - STRAIN CURVES
"A" NICKEL
.109 GAGE SHEET

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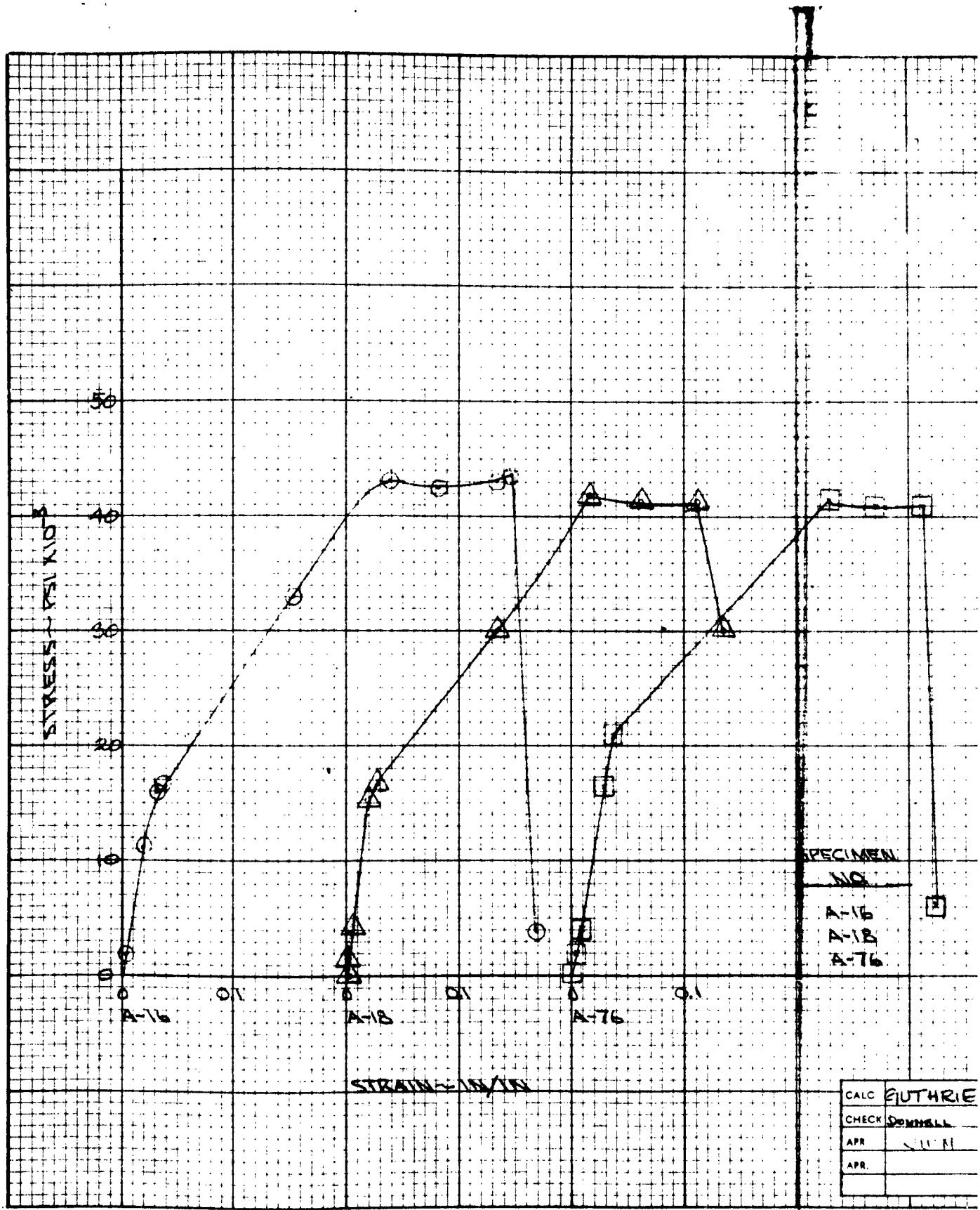
D2-80086

BOEING AIRPLANE COMPANY

PAGE 1-46

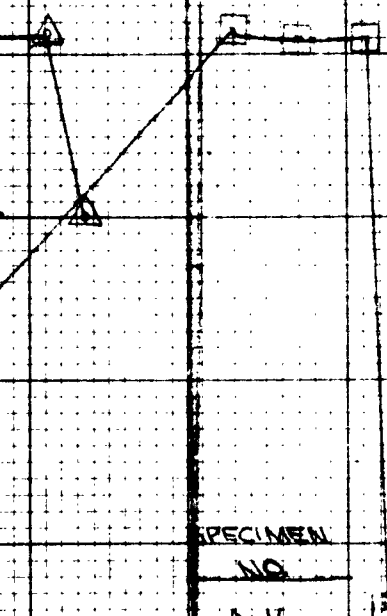
CONTRACT NO.



CALC	GUTHRIE
CHECK	DONNELL
APR	
APR.	

DATA SHEET

CONTRACT NO.



SPEC. NO.	ENERGY TO ULT. IN-LB/LB	ENERGY TO FAIL IN-LB/LB
A-16	34,400	36,100
A-18	29,600	32,400
A-76	30,200	31,200

STRAIN -IN/IN

0.1

STRAIN RATE -IN/IN/MIN

190 TYP.

2

SPECIMEN NO.	AREA -SQ.IN.	FTU -PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
A-16	.0544	43,800	LONG.	600°	AIR
A-18	.0551	41,900	LONG.	600°	AIR
A-76	.0549	41,300	LONG.	600°	AIR

0.1

			REVISED	DATE
CALC	GUTHRIE	1-27-61		
CHECK	DONNELL	1-28-61		
APR				
APR.				

STRESS-STRAIN CURVES
"A" NICKEL
.109 GAGE SHEET

BOEING AIRPLANE COMPANY

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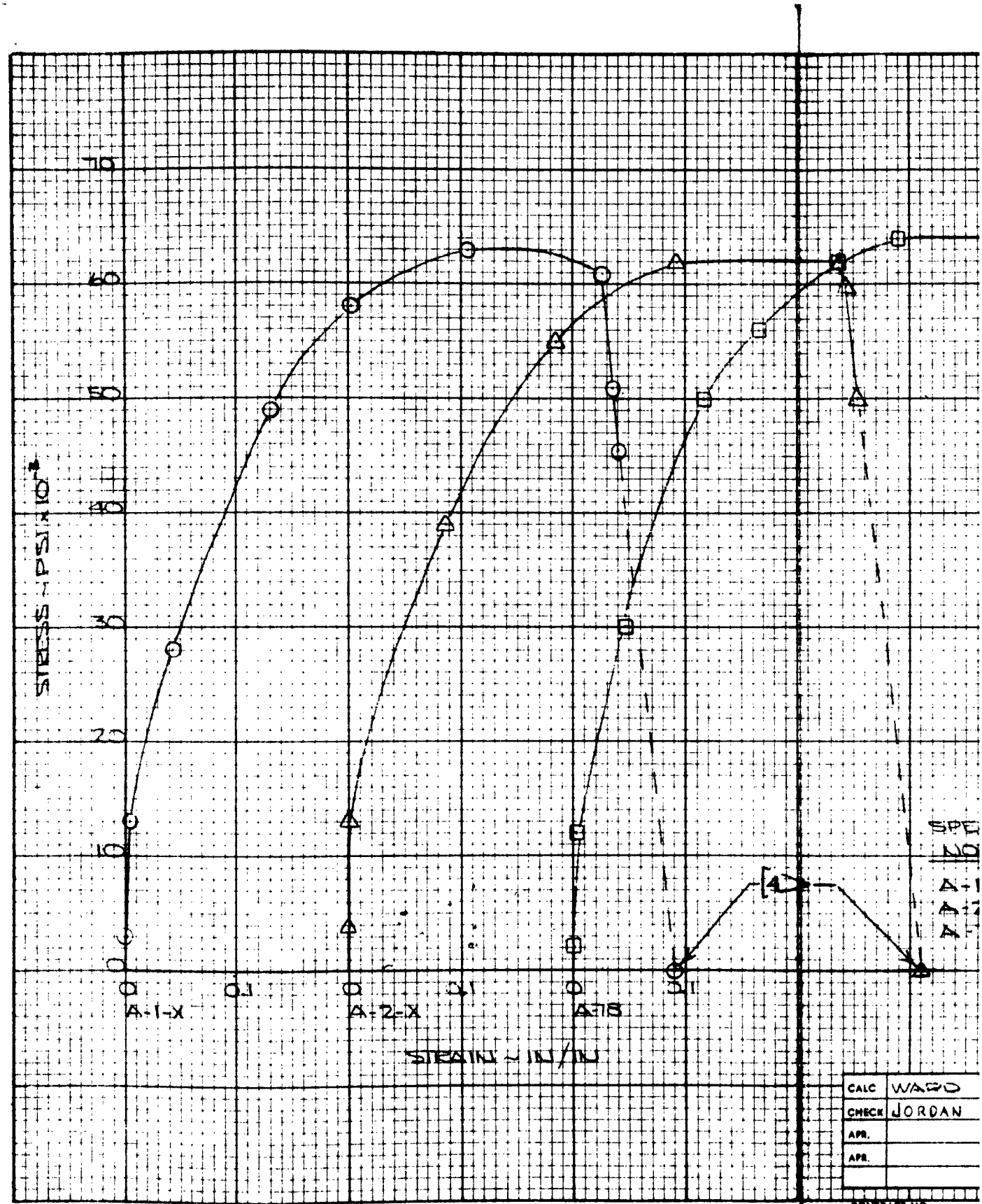
PAI 1-47

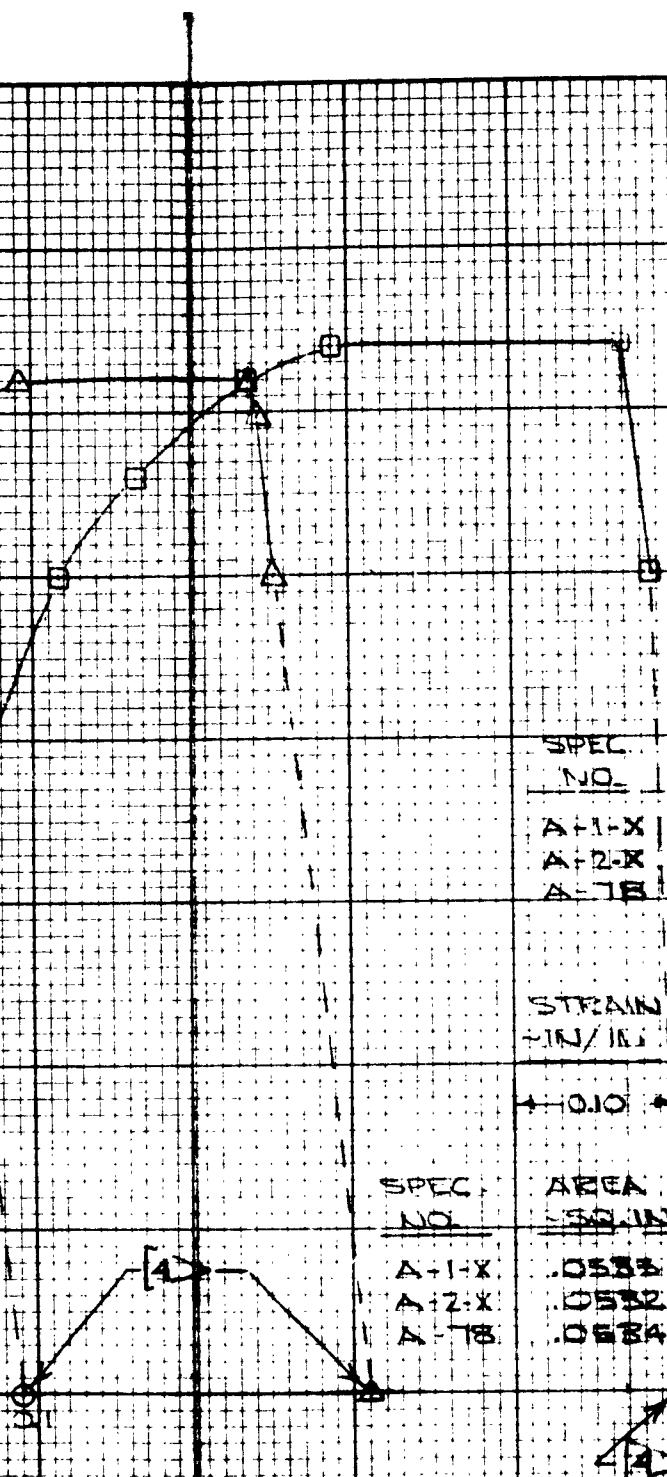
CONTRACT NO.



CALC	WARD
CHECK	JORDAN
APP.	
APP.	

DATA SHEET

CONTRACT NO.



2

SPEC. NO.	ENERGY TO ULT. - IN-LB/LB	ENERGY TO FAIL. - IN-LB/LB
A-1-X	68,440	74,330
A-2-X	69,750	76,730
A-78	78,970	83,120

STRAIN +IN/IN	STRAIN RATE +IN/IN/MIN
+0.10	200

SPEC. NO.	AREA - SQ.IN	FTU - PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
A-1-X	.0555	63,000	LONG.	-65	NITROGEN
A-2-X	.0552	62,000	LONG.	-65	NITROGEN
A-78	.0554	64,000	LONG.	-65	NITROGEN

+SEE PAGE 1-20 FOR NOTES

			REVISED	DATE
CALC	WARD	3-22-1		
CHECK	JORDAN	3-28-1		
APR.				
APR.				

CONTRACT NO.

STRESS-STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A

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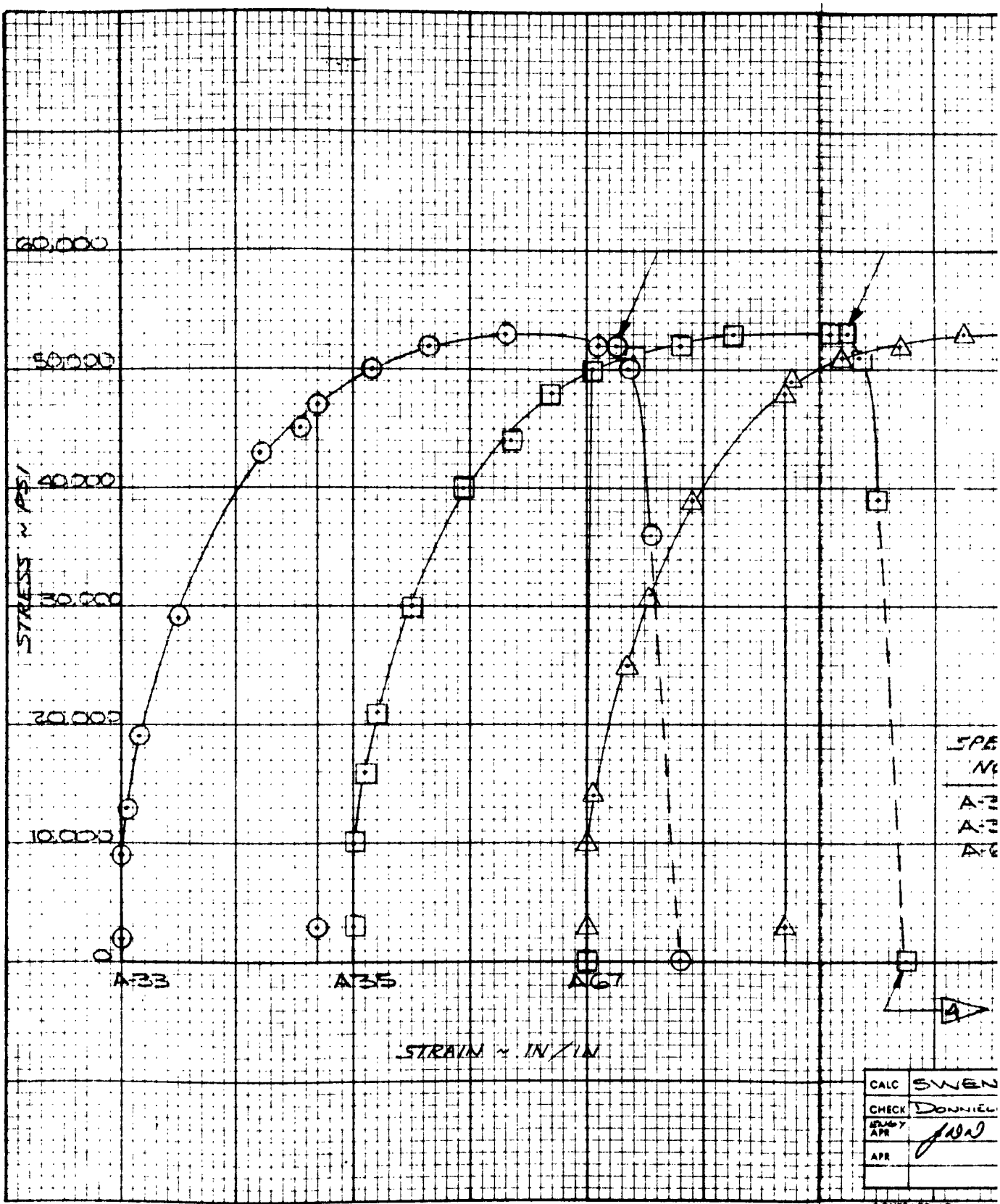
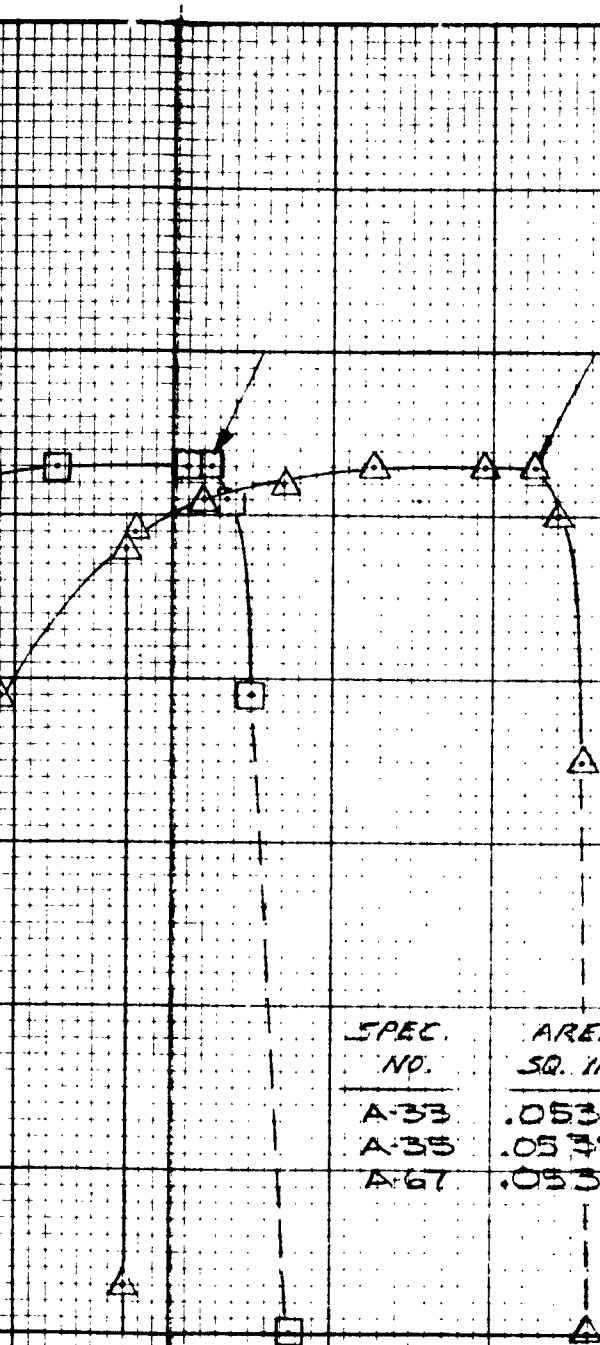


DATA SHEET

CONTRACT NO

U3 4011 5000—REV 7/60 (WAS BAC 360D)



SPEC. NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-33	59,200	65,200
A-35	59,300	64,200
A-67	59,800	64,700

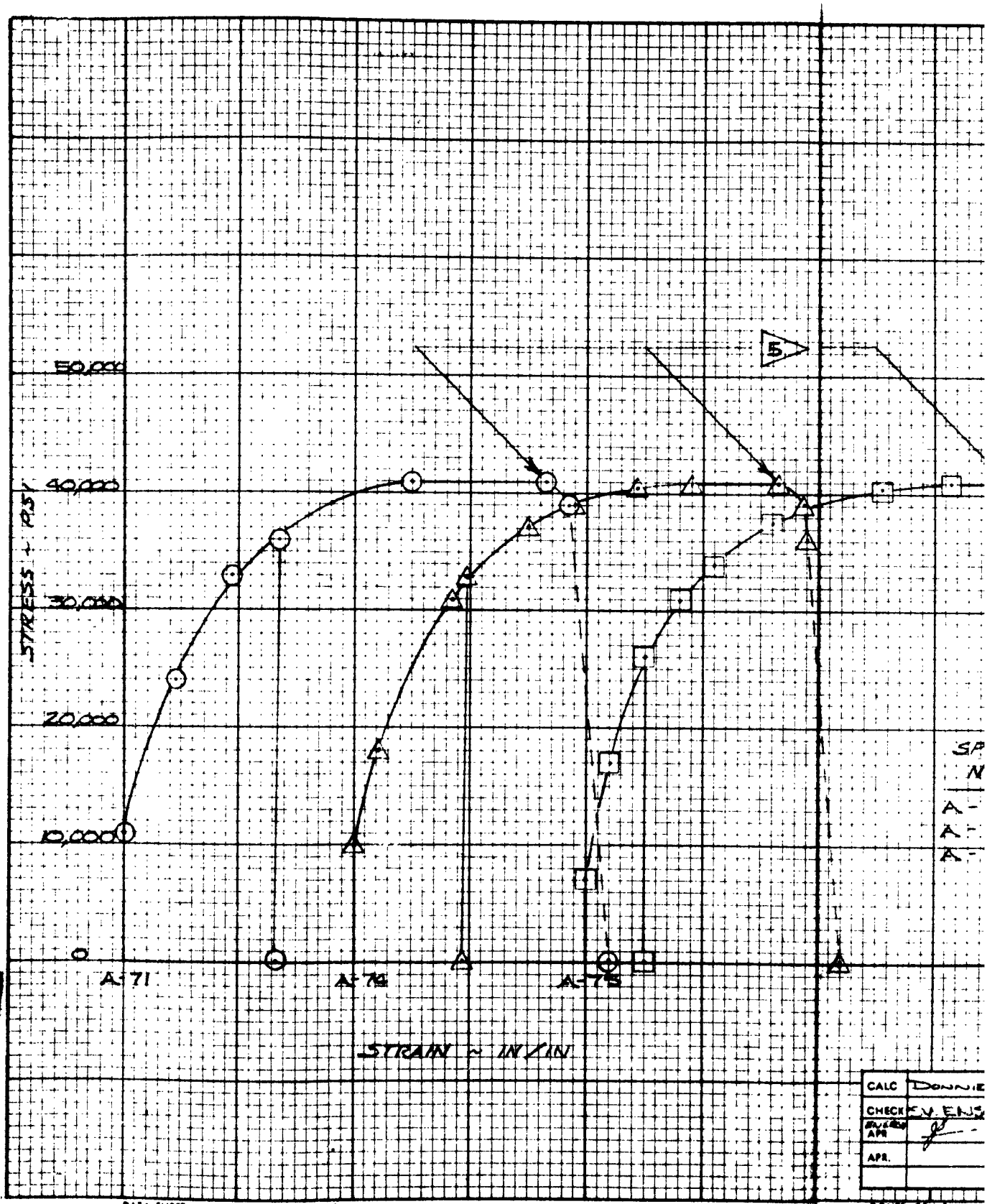
STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	200

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
A-33	.0535	53,000	LONG	250	AIR
A-35	.0538	53,000	LONG	250	AIR
A-67	.0538	53,000	LONG	250	AIR

SEE PAGE 1-20 FOR NOTES

			REVISED	DATE	STRESS STRAIN CURVES NICKEL A .109 GAGE SHEET	X-20A
CALC	SWEN	5-18-1				D2-80086
CHECK	DONNELL	5-18-1			BOEING AIRPLANE COMPANY	PAGE 149
STRUCT APR.						
APR.						

CONTRACT NO.



1

CALC	DONNIE
CHECK	V. ENG.
APR	
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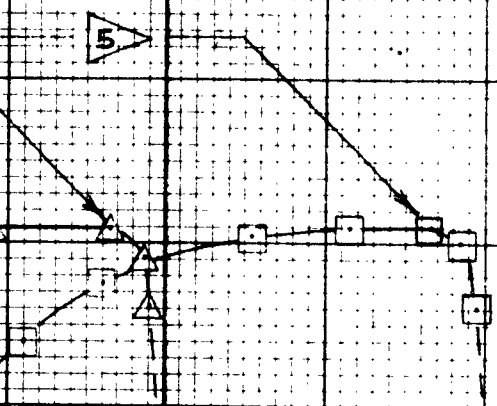
DATA SHEET

CONTRACT NO.

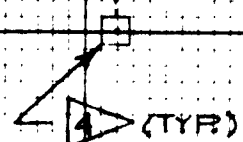
US 4011 8000—REV. 7/60 (WAS BAC 3600)



SPEC. NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-71	40,000	44,250
A-74	39,400	44,100
A-75	39,600	44,250

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	200

SPEC NO.	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-71	.0547	41,000	LONG	800	AIR
A-74	.0548	41,000	LONG	800	AIR
A-75	.0548	41,000	LONG	800	AIR

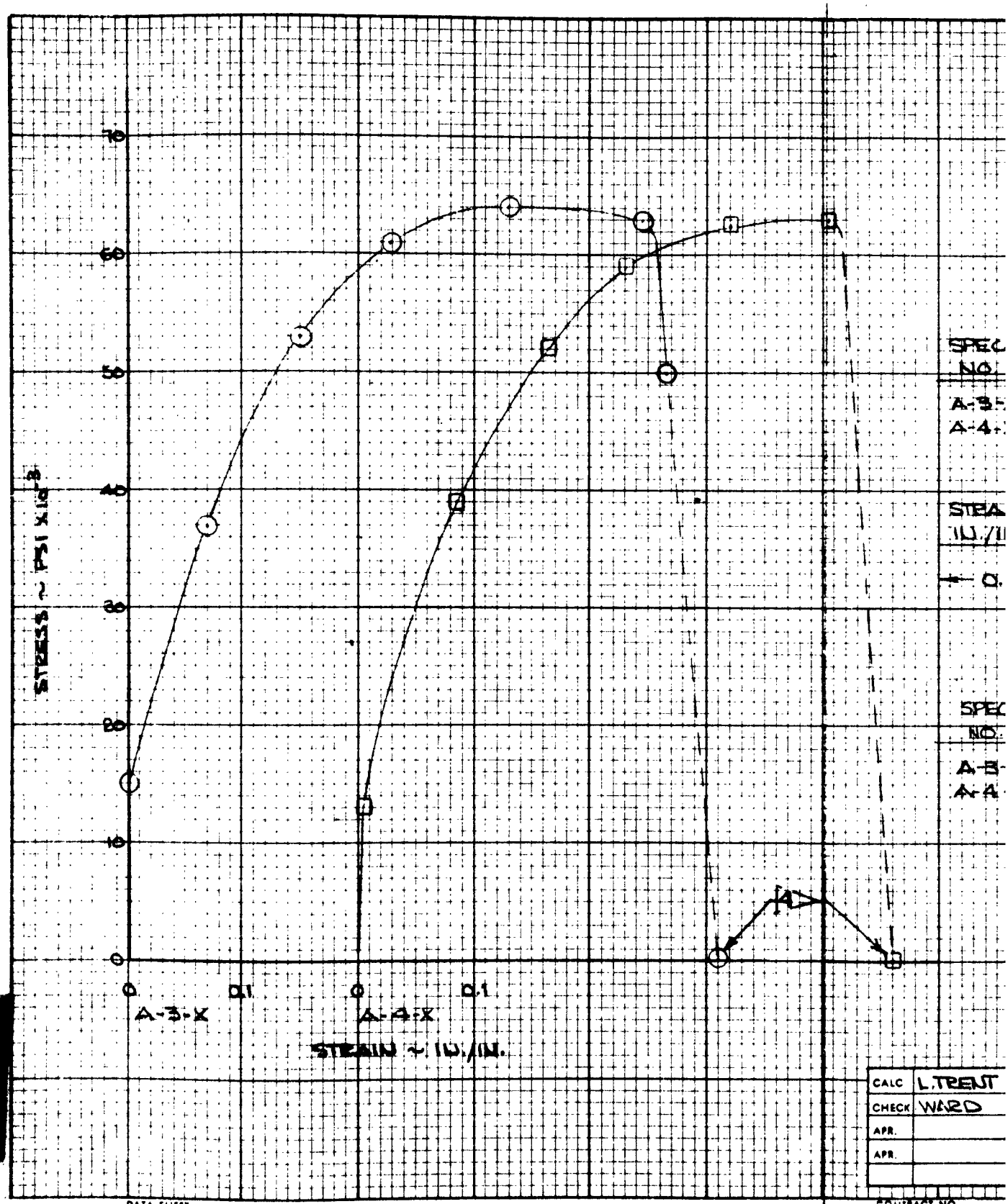


SEE PAGE 420 FOR NOTES

2

CALC	DONNELL 5-18-1	REVISED	DATE	STRESS STRAIN CURVES NICKEL "A" .109 GAGE SHEET	X-20A
CHECK	C.V. ENJOUVIN 5-18-1				D2-8008G
ENGRG APR				BOEING AIRPLANE COMPANY	PAGE 450
APR.					

CONTRACT NO.



DATA SHEET

CONTRACT NO.

U3 4011 5000—REV. 7/60 (WAS BAC 360D)

SPEC NO.	ENERGY TO ULT ~ IN-LB/LB.	ENERGY TO FAIL ~ IN-LB/LB.
A-3-X	73,990	81,310
A-4-X	63,490	69,780

STRAIN IN./IN.	STRAIN RATE IN./IN./MIN.
← 0.1 →	300

2

SPEC NO.	AREA SQ. IN.	FTU ~ PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
A-3-X	.0551	69,000	LONG.	-65	NITROGEN
A-4-X	.0528	63,000	LONG.	-65	NITROGEN

~ SEE PAGE 152 FOR NOTES ~

			REVISED	DATE
CALC	L. TRENT	3-22-1		
CHECK	WARD	3-23-1		
APR				
APR.				

STRESS-STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

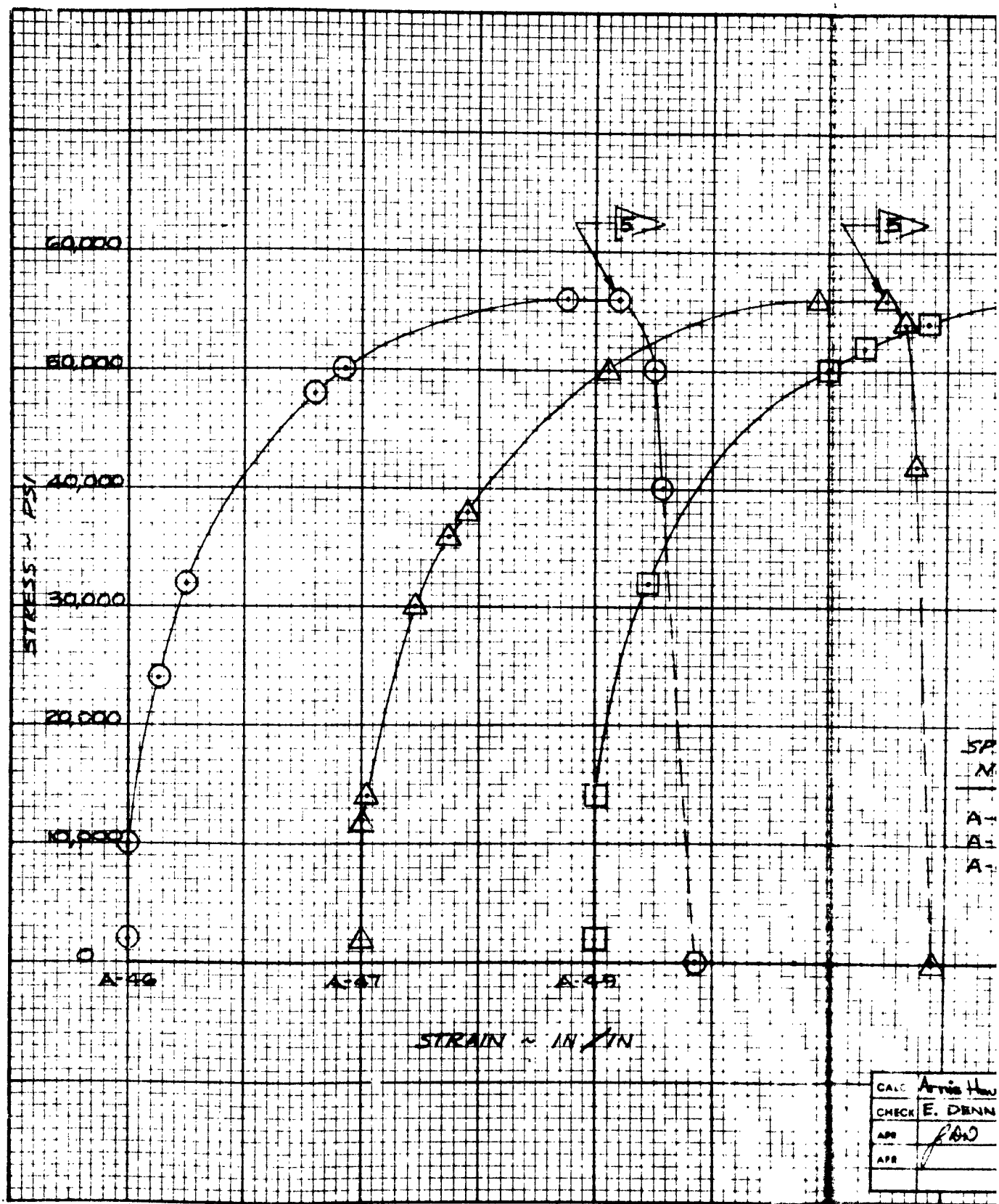
X-20A

D2-80086

BOEING AIRPLANE COMPANY

PAGE 151

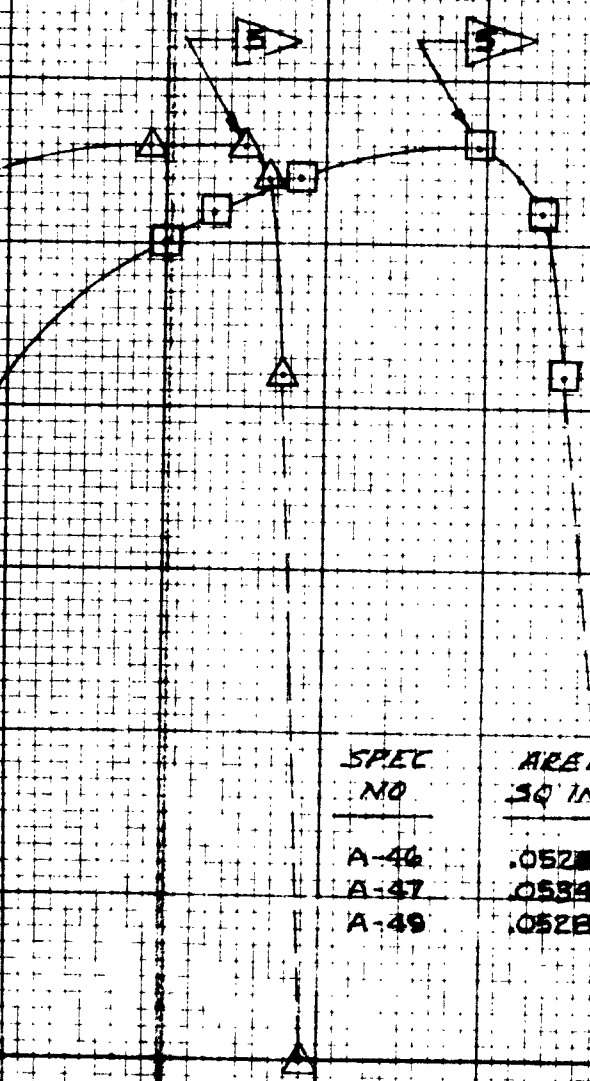
CONTRACT NO.



DATA SHEET

U3 4011 5000—REV 7/60 (WAS BAC 360D)

CONTRACT NO.



SPEC NO.	ENERGY TO FTU IN-LB/LB.	ENERGY TO FAILURE IN-LB/LB
A-46	61,000	68,750
A-47	64,800	69,850
A-49	56,700	68,250

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	300

SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-46	.0528	56,000	LONG.	250	AIR
A-47	.0534	56,000	LONG.	250	AIR
A-49	.0528	56,000	LONG.	250	AIR

SEE PAGE 1-53 FOR NOTES

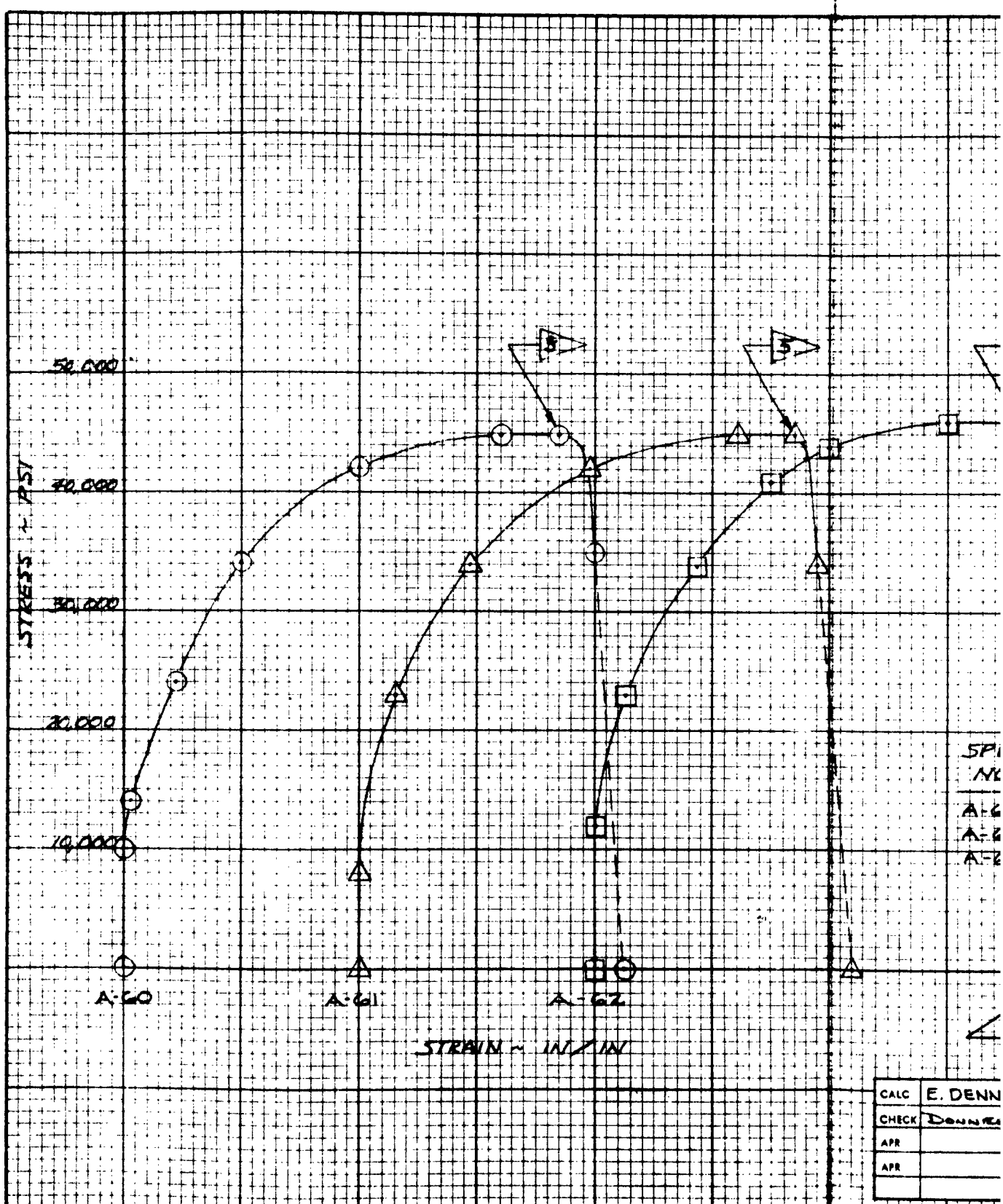
			REVISED	DATE
CAL	Arnie Hauge	5-9-61		
CHECK	E. DENNEY	5-9-61		
APR	[illegible]	5-11-61		
APR				

STRESS STRAIN CURVES
NICKEL "A"
.109 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A
D2-80086
PAGE 1-52

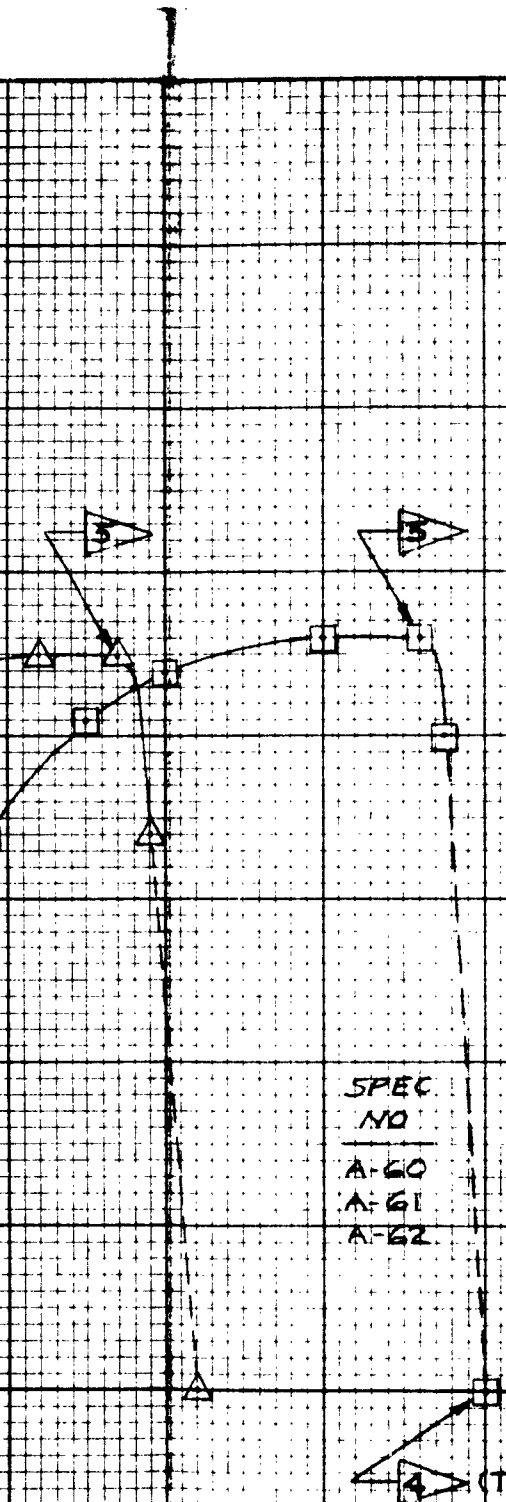
CONTRACT NO.



CALC	E. DENN
CHECK	DONNE
APR	
APR	

DATA SHEET

CONTRACT NO.



SPEC. NO	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
A-60	42,900	48,200
A-61	43,100	47,500
A-62	45,250	47,000

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	300

SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
A-60	.0542	45,000	LONG.	600	AIR
A-61	.0545	45,000	LONG.	600	AIR
A-62	.0536	46,000	LONG.	600	AIR

SEE PAGE 1-20 FOR NOTES

2

CALC	E. DENNEY	5/9/61	REVISED	DATE	STRESS STRAIN CURVES NICKEL "A" .109 GAGE SHEET
CHECK	DONNELL	5-12-61			
APR					
APR					

BOEING AIRPLANE COMPANY

X-20A

D2-80086

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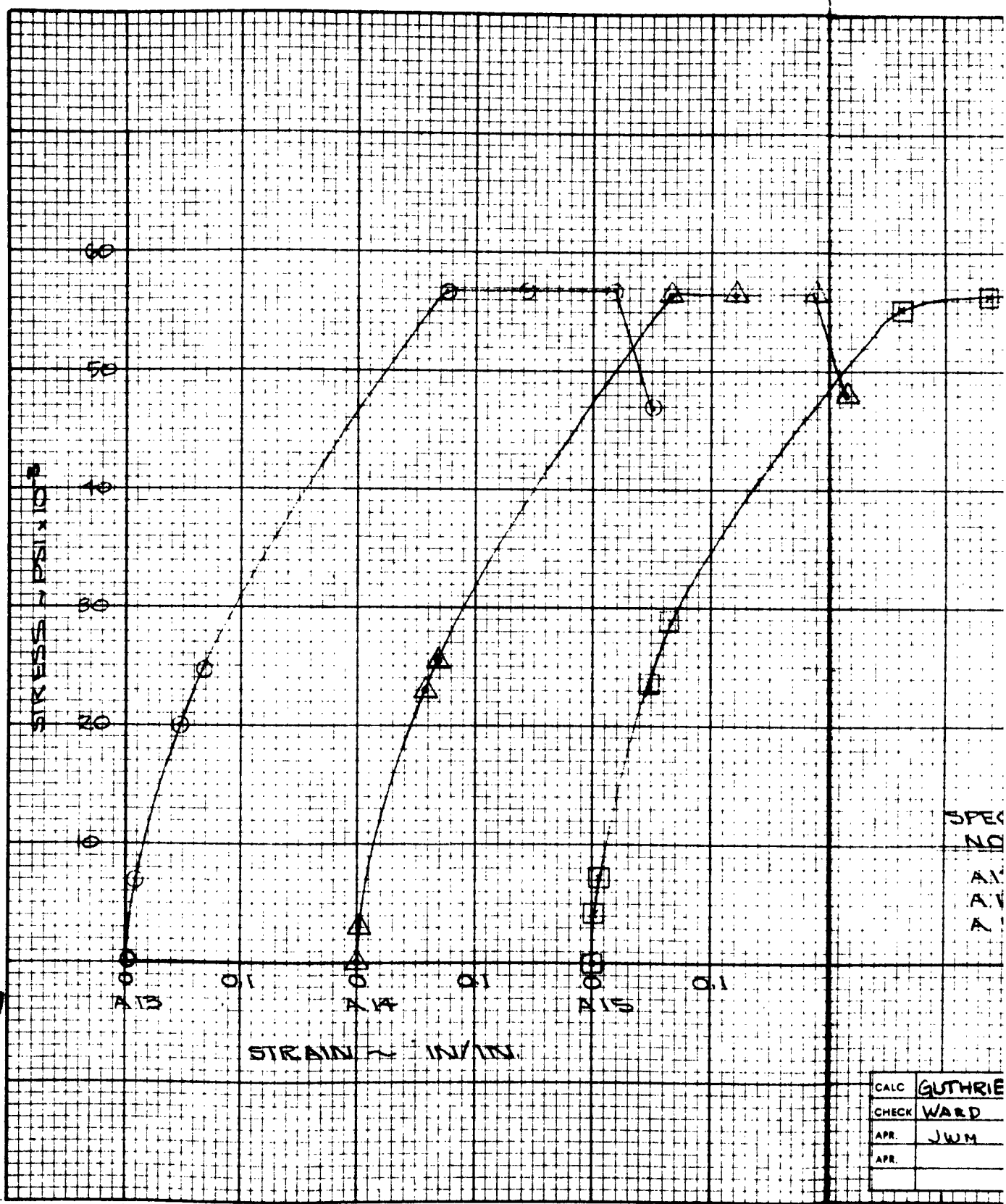
CONTRACT NO.



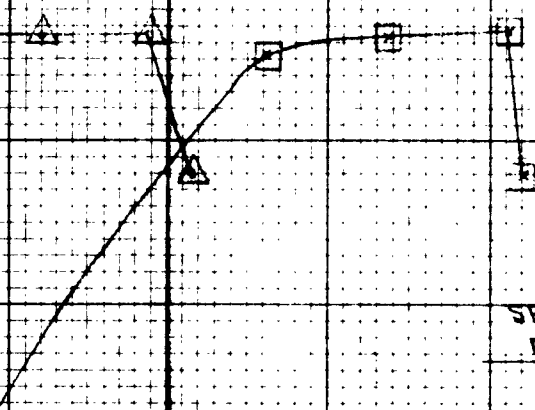
SPEC
NO
A
A
A

CALC	GUTHRIE
CHECK	WARD
APR.	JWM
APR.	

DATA SHEET

CONTRACT NO.

U3 4011 5000—REV. 7/60 (WAS BAC 360D)



SPEC. NO.	ENERGY TO ULT. IN-LB/LB	ENERGY TO FAIL IN-LB/LB
A13	55,500	60,500
A14	50,000	54,200
A15	56,000	57,500

STRAIN ~IN./IN.	STRAIN RATE ~IN./IN./MIN.
←0.1→	280 IN/IN./MIN. (TYP)

SPEC. NO.	AREA ~SQ.IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP (°F)	TEST ATMOS.
A13	.0547	56,800	LONG.	72	AIR
A14	.0546	56,600	LONG.	72	AIR
A15	.0547	56,800	LONG.	72	AIR

2

			REVISED	DATE
CALC	GUTHRIE	1-27-61		
CHECK	WARD	1-27-61		
APR.	JWM	1-28-61		
APR.				

STRESS - STRAIN CURVES
"A" NICKEL
.109 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A

D2-8008

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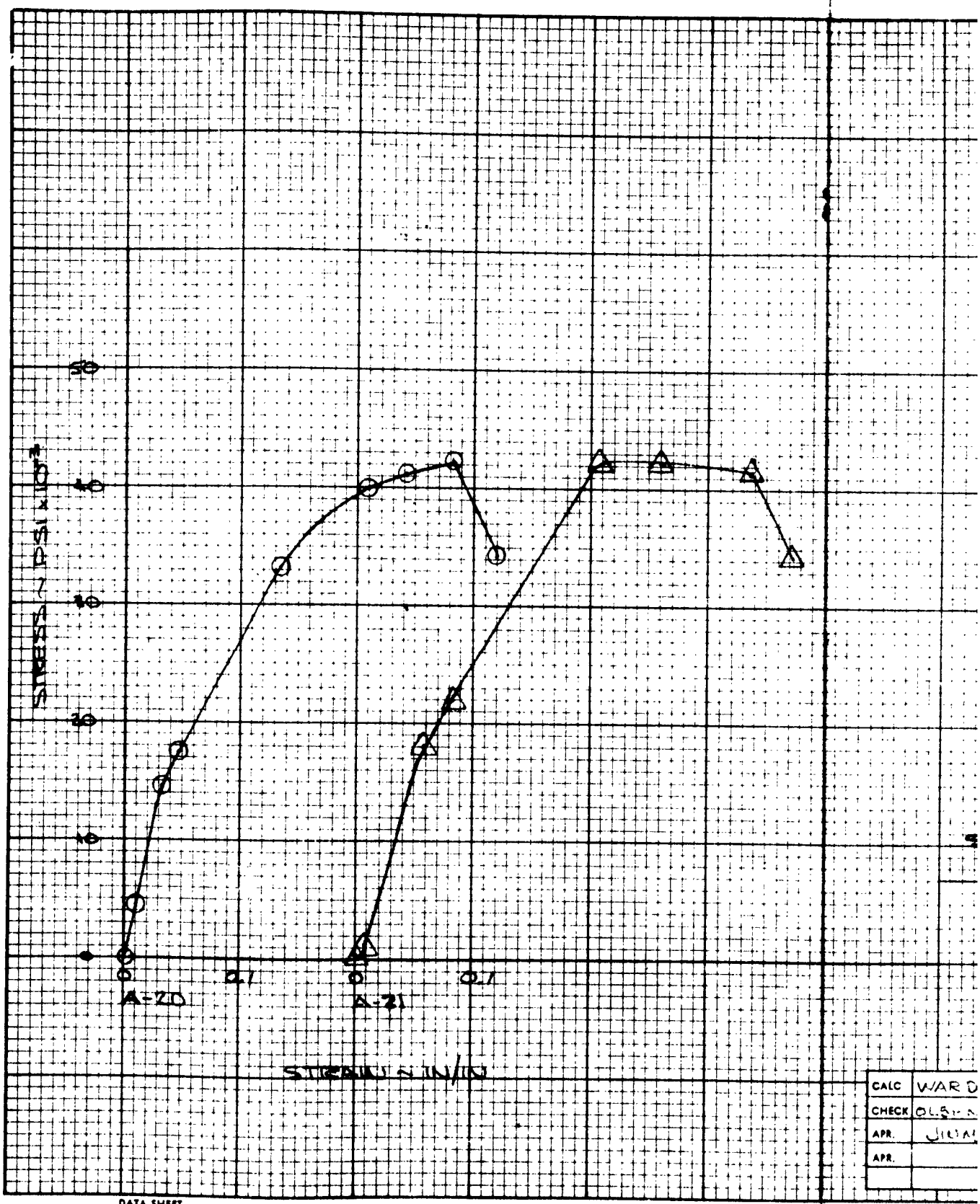
CONTRACT NO.



CALC	WARD
CHECK	OLSON
APR.	JIRAN
APR.	

DATA SHEET

CONTRACT NO.

U3 4011 5008—REV. 7/60 (WAS BAC 360D)

2

SPECIMEN NO.	ENERGY TO ULT ~IN-LB/LB	ENERGY TO FAILURE ~IN-LB/LB
A-20	26,200	20,800
A-21	32,600	34,800

STRAIN ~IN/IN

±0.1

STRAIN RATE ~IN/IN/MIN

200 (TYP)

SPECIMEN NO.	AREA ~SQ.IN.	ETU ~PSI	GRAIN DIRECTION	TEST TEMP(°F)	TEST ATMOS
A-20	.0552	42,200	LONG.	800	AIR
A-21	.0552	42,200	LONG.	800	AIR

			REVISED	DATE
CALC	WARD	1-27-61		
CHECK	OLSON	1-27-61		
APR.	JILLA	1-28-61		
APR.				

STRESS-STRAIN CURVES
"A" NICKEL
.109 GAGE SHEET

X-20A

D2-80086

BOEING AIRPLANE COMPANY

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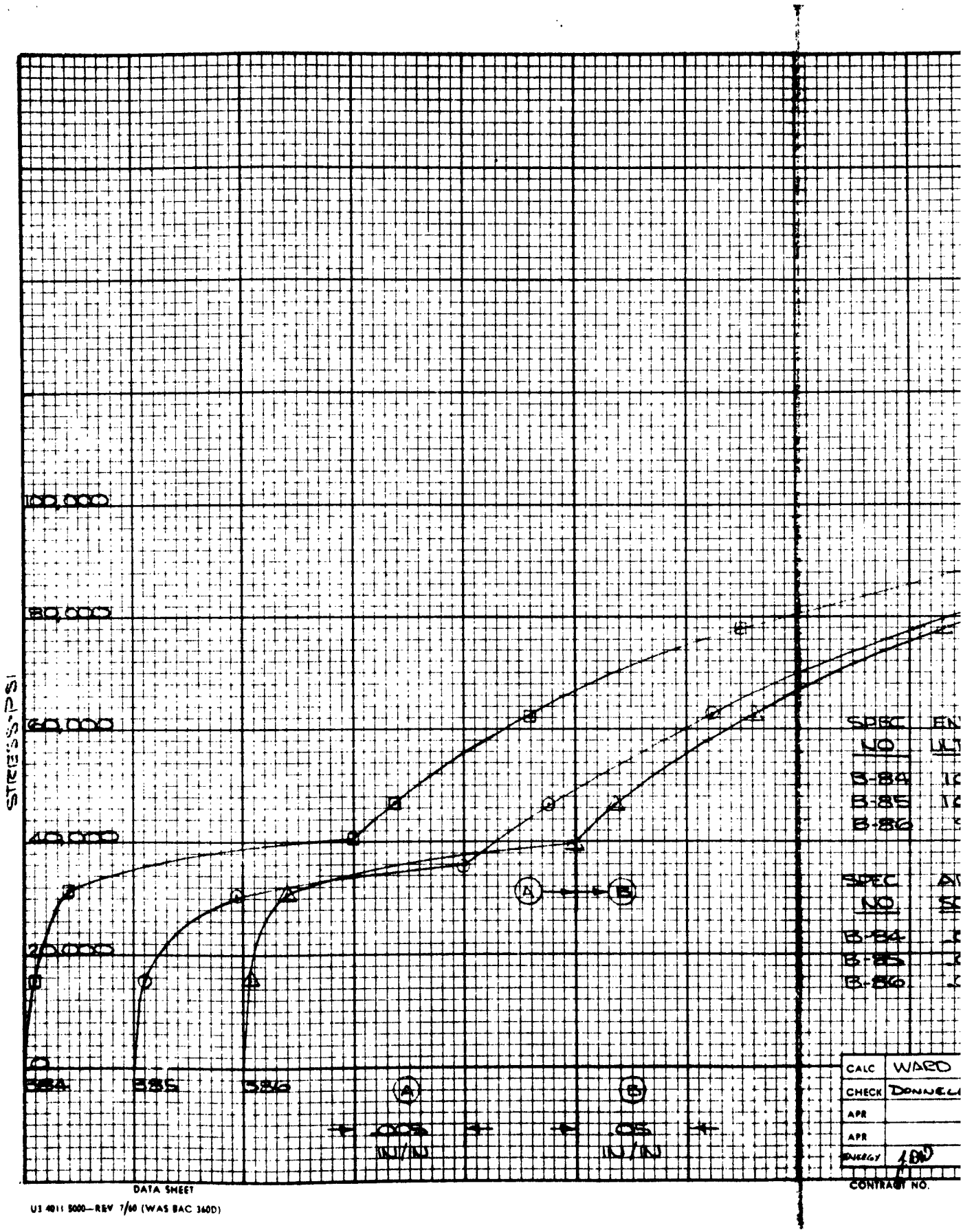
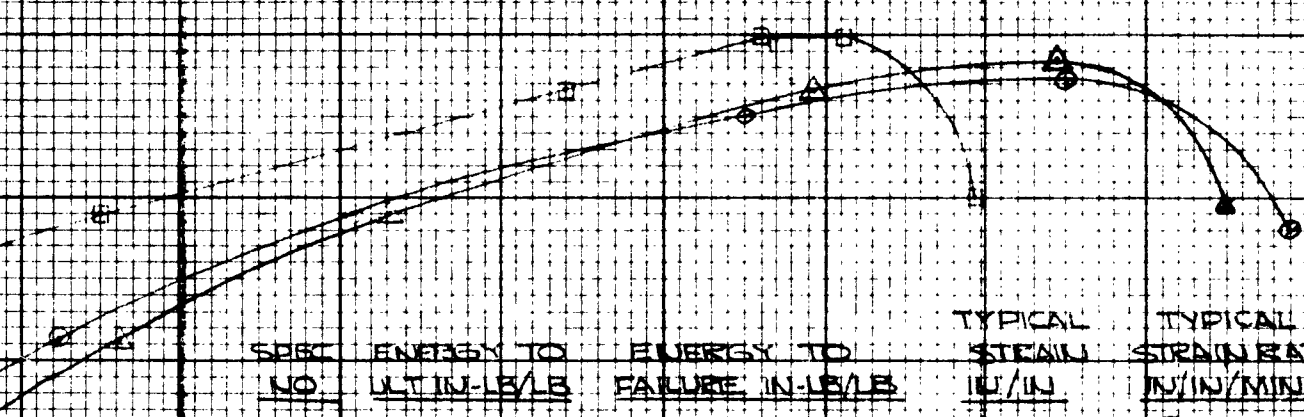
CONTRACT NO


STRESS-PSI
100,000
80,000
60,000
40,000
20,000
0
B84
B85
B86
A
B
.005
IN/IN
.05
IN/IN
SPEC NO.
B-84
B-85
B-86
SPEC NO.
B-84
B-85
B-86
CALC WARD
CHECK DONNELL
APR
APR
ENERGY 180
CONTRACT NO.
DATA SHEET
U3 4011 5000—REV 7/60 (WAS BAC 360D)

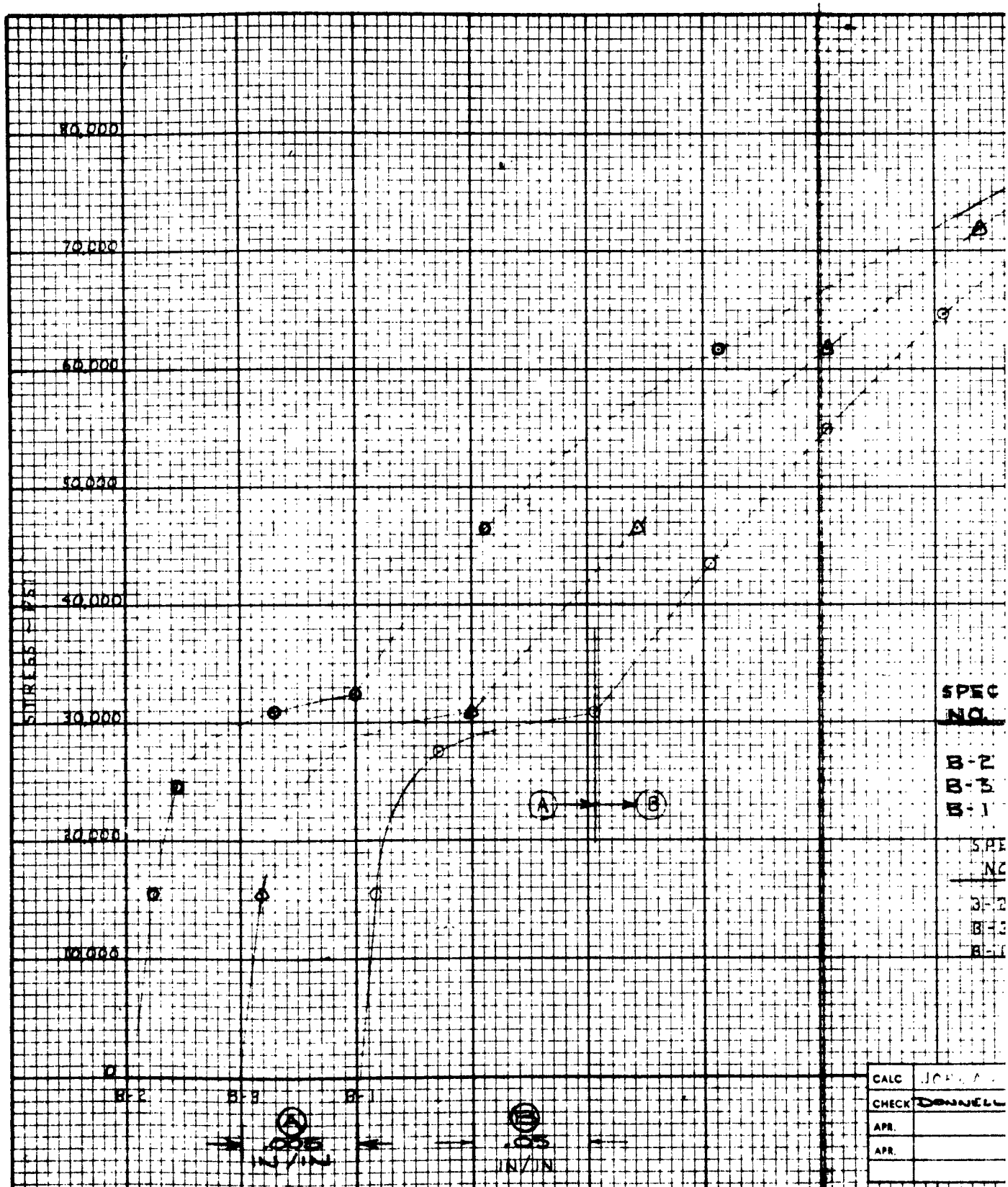


SPEC NO.	ENERGY TO ULT IN-LB/LB	ENERGY TO FAILURE IN-LB/LB	TYPICAL STRAIN IN/IN	TYPICAL STRAIN RATE IN/IN/MIN
B-84	107,000	120,000	(A) = .005	(A) = .005
B-85	104,800	127,500	(B) = .05	(B) = .10
B-86	98,400	113,700		

SPEC NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOSPHERE
B-84	.0640	96,900	LONG.	-65	NITROGEN
B-85	.0640	94,500	LONG.	-65	NITROGEN
B-86	.0640	97,200	LONG.	-65	NITROGEN

CALC	WARD	2-24-61	REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CHECK	DONNELL	3-6-61				D2-80086
APR					BOEING AIRPLANE COMPANY	PAGE 1-56
APR						
ENERGY	1 BTU					

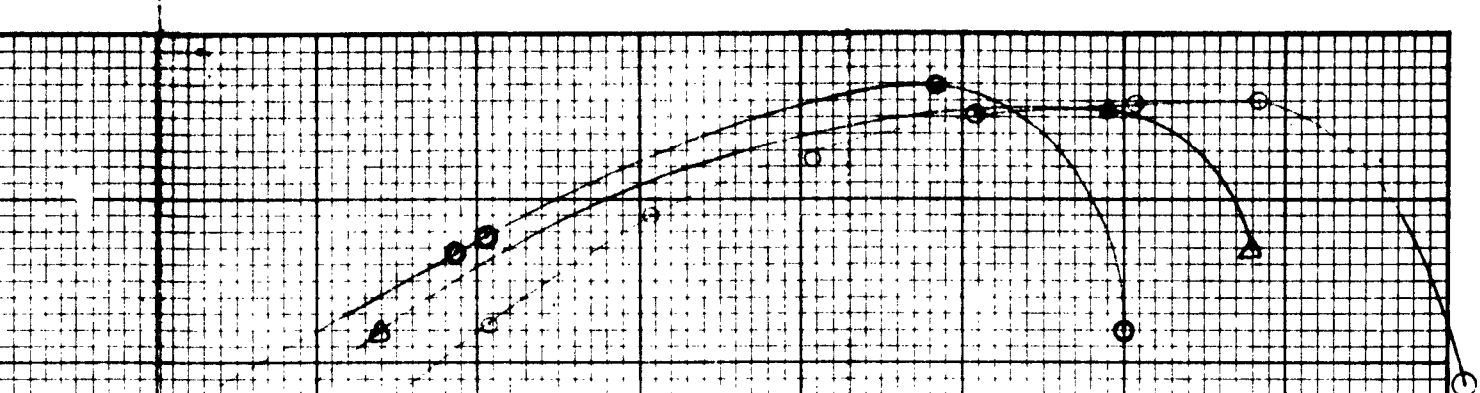
CONTRACT NO.



CALC	
CHECK	DONNELL
APR.	
APR.	

DATA SHEET

CONTRACT NO.



SPEC NO.	ENERGY TO ULT IN-lb/in³	ENERGY TO FAIL IN-lb/in³	TYP. STRAIN IN/IN	TYP. STRAIN RATE IN/IN/MIN
B-2	99,276	115,168	(A) = .005	(A) = .005
B-3	101,261	113,701		
B-1	102,107	118,367	(B) = .05	(B) = .10

SPEC NO.	AREA ~50 IN	PTO ~PSI	STRAIN DIRECT.	TEST TEMP (°F)	TEST ATMOS.
B-2	.0448	87,000	LONG.	72	AIR
B-3	.0485	85,600	LONG	72	AIR
B-1	.0444	86,000	LONG	72	AIR

2

CALC	JO... A	1-14-61	REVISED	DATE	STRESS STRAIN CURVES INCONEL .127 GAGE SHEET
CHECK	DONNELL	1-14-61			BOEING AIRPLANE COMPANY
APR.					
APR.					

X-20A

D2-80086

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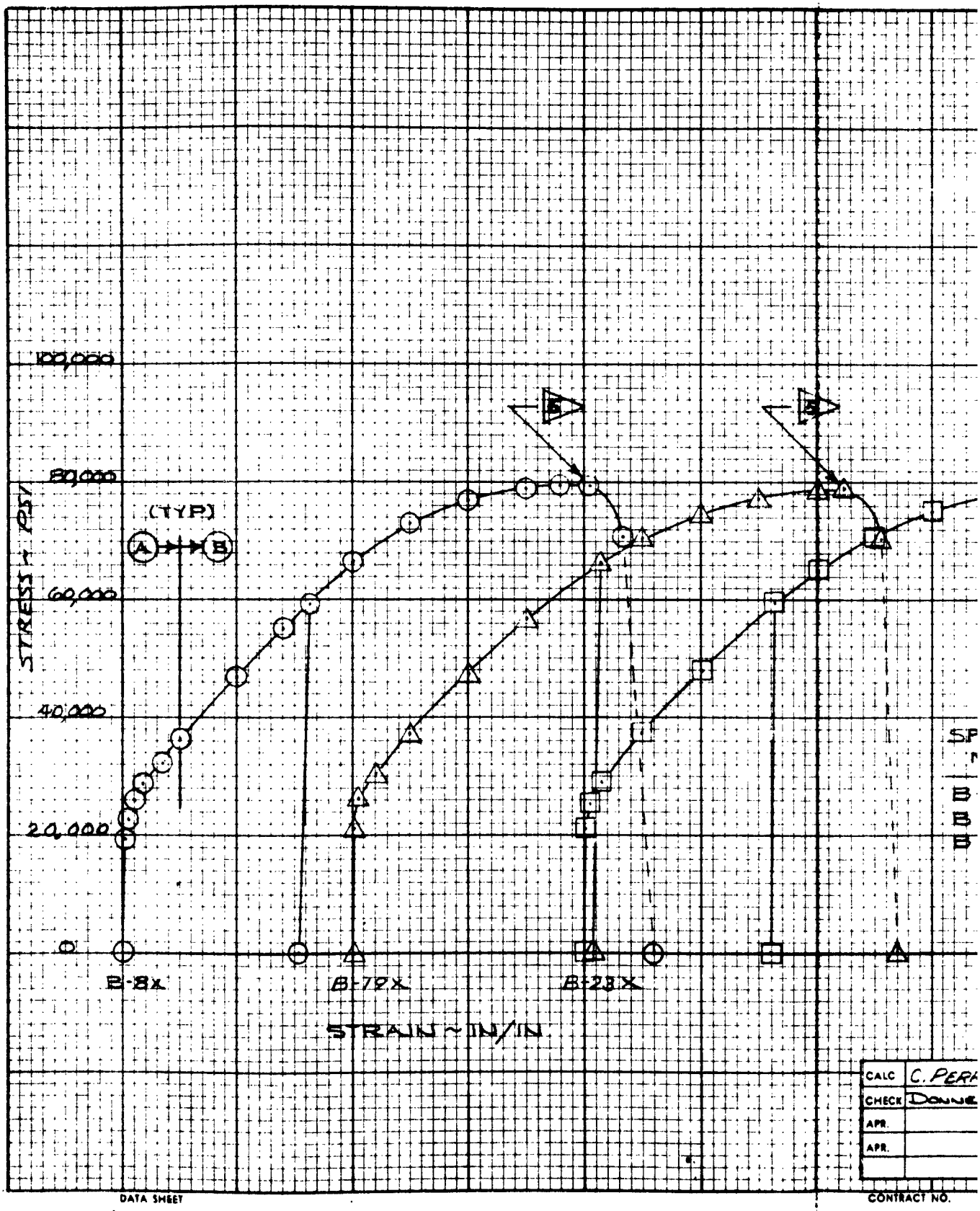
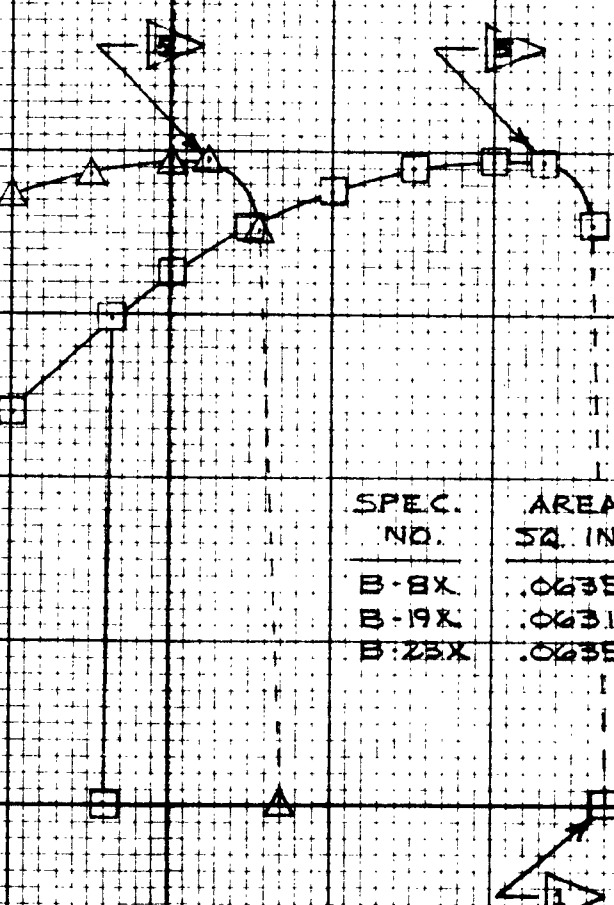
CONTRACT NO.



DATA SHEET

CONTRACT NO.

U3 4011 5008—REV. 7/68 (WAS BAC 360D)



SPEC. NO.	ENERGY TO FTU IN.-LB./LB.	ENERGY TO FAILURE IN-LB./LB.
B-8X	81,800	92,200
B-19X	86,200	95,700
B-23X	88,100	97,100

STRAIN IN./IN.

←.10→

STRAIN RATE IN./IN./MIN.

(A) = .005

(B) = .05

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
B-8X	.0635	79,700	LONG.	250	AIR
B-19X	.0631	79,200	LONG.	250	AIR
B-23X	.0635	79,100	LONG.	250	AIR

SEE PAGE 12 FOR NOTES

			REVISED	DATE
CALC	C. PERRY	5-5-61		
CHECK	DONNELL	5-5-61		
APR.				
APR.				

STRESS STRAIN CURVES
INCONEL
.127 GAGE SHEET

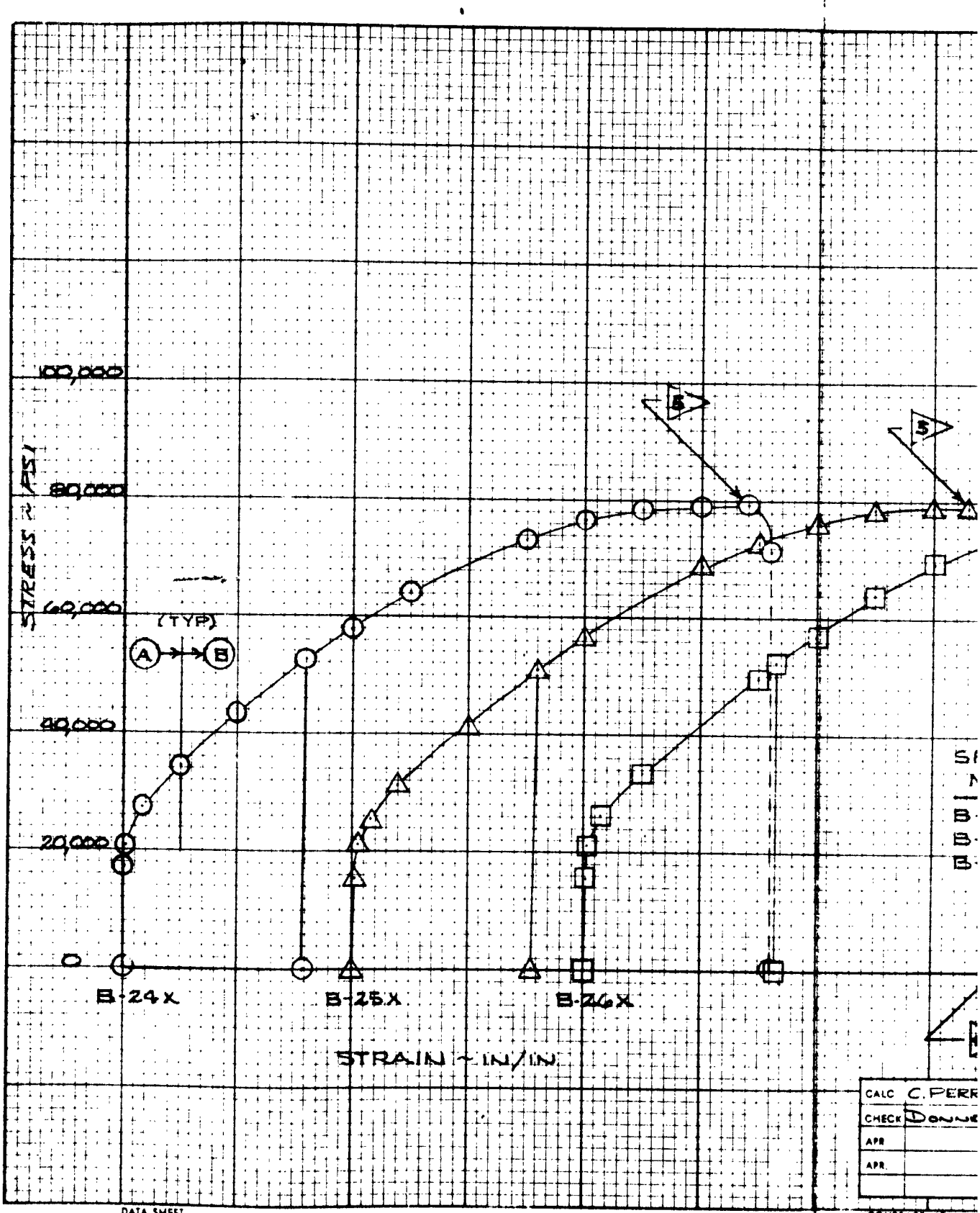
BOEING AIRPLANE COMPANY

X-20A

D2-8008L

PAGE 458

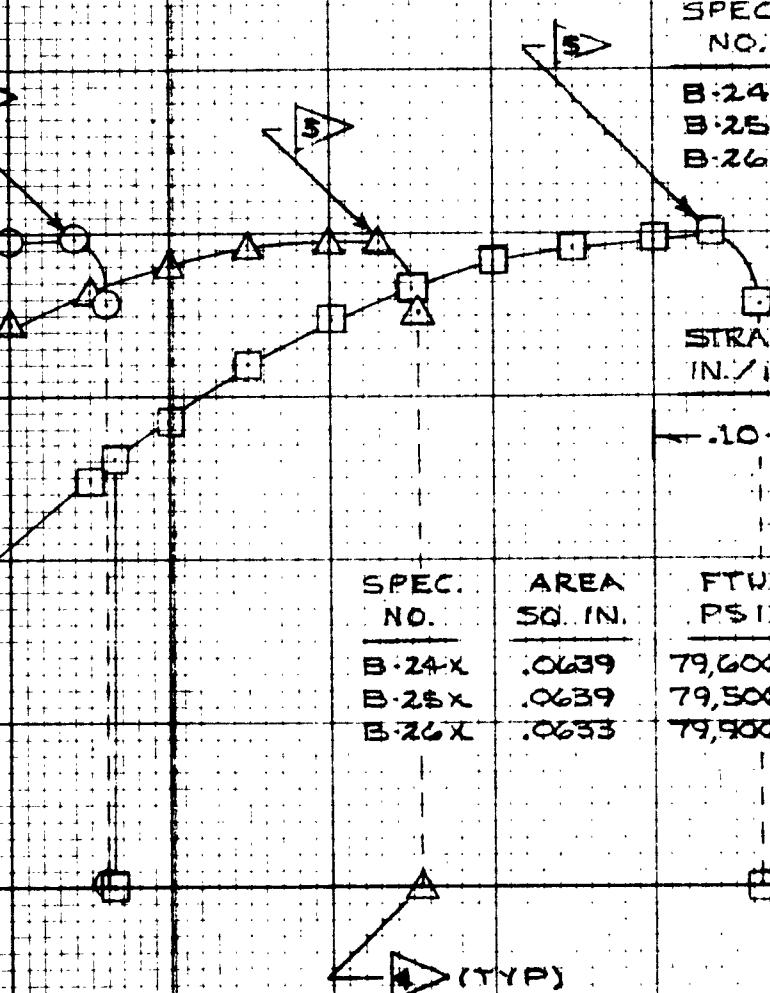
CONTRACT NO.



DATA SHEET

US 4011.5000—REV 7/60 (WAS BAC 360D)

CONTRACT NO.



SPEC. NO.	ENERGY TO FTU IN-LB/LB.	ENERGY TO FAILURE IN-LB./LB.
B-24X	110,200	115,200
B-25X	105,800	112,300
B-26X	107,700	115,300

STRAIN IN./IN.

.10

STRAIN RATE IN./IN./MIN.

(A) = .005

(B) = .05

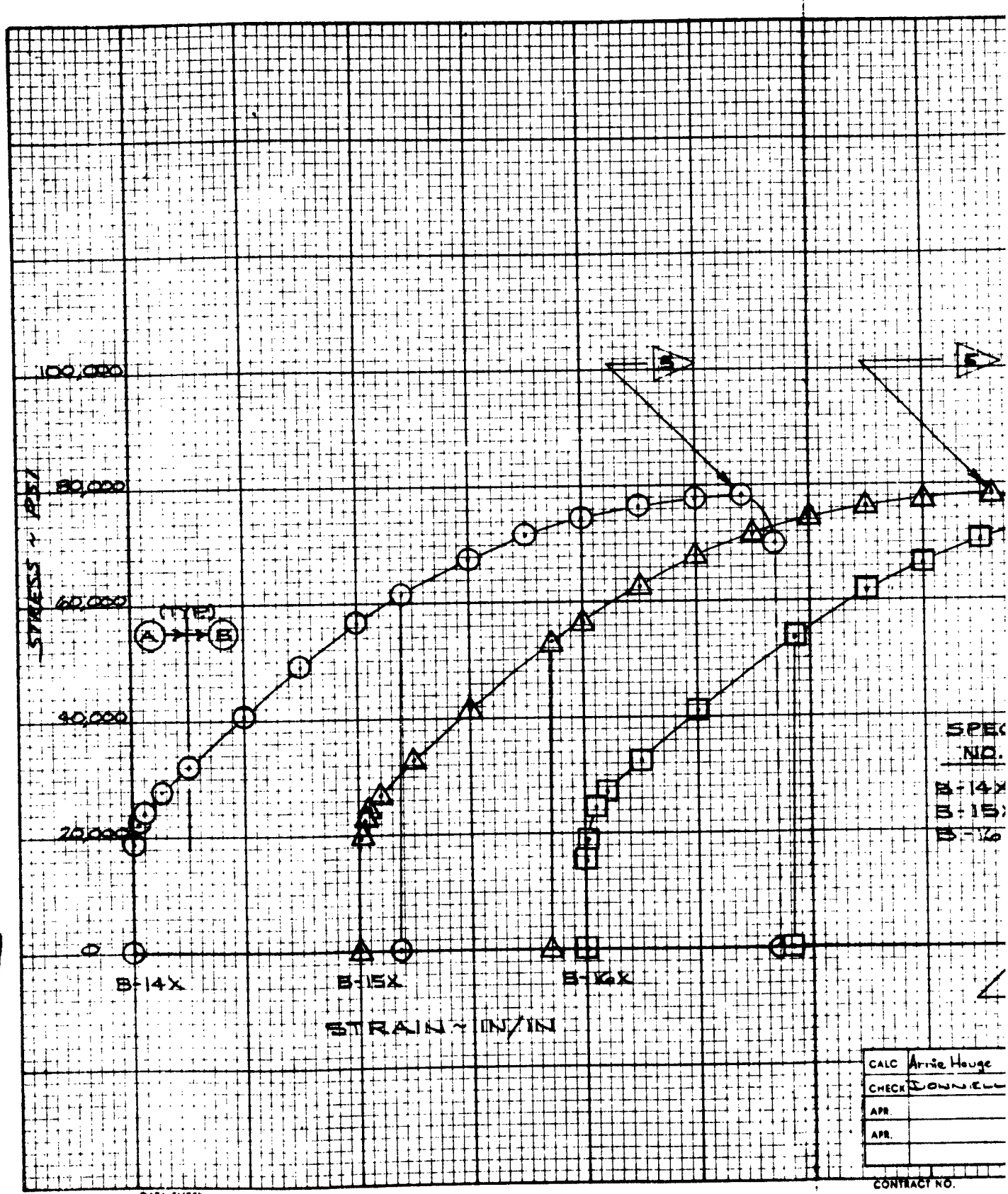
2

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
B-24X	.0639	79,600	LONG.	600	AIR
B-25X	.0639	79,500	LONG.	600	AIR
B-26X	.0633	79,900	LONG.	600	AIR

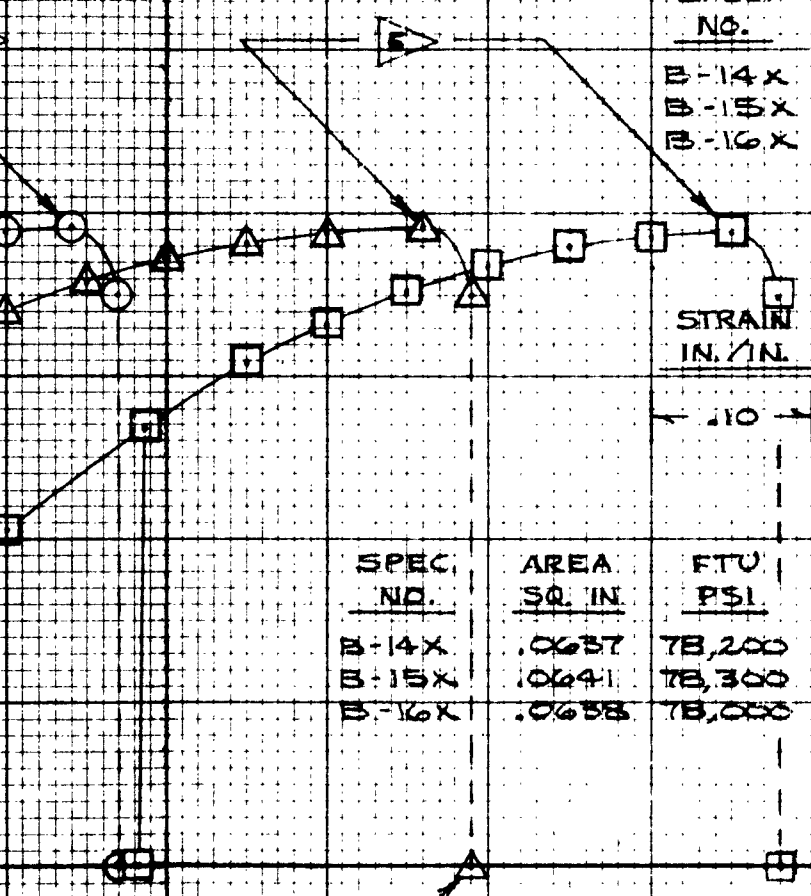
SEE PAGE 1-20 FOR NOTES

CALC C. PERRY 5-5-1	REVISED	DATE	STRESS STRAIN CURVES	X-20A
CHECK DONNELL 5-8-1			INCONEL .127 GAGE SHEET	D2-80086
APR			BOEING AIRPLANE COMPANY	PAGE 1-59
APR				

CONTRACT NO.


100,000
80,000
60,000
40,000
20,000
0
STRESS ~ PSI
(TYP)
A
B
B-14X
B-15X
B-16X
STRAIN ~ IN/IN
SPEC
NO.
B-14X
B-15X
B-16
CALC Arnie Heuge
CHECK
APR.
APR.
CONTRACT NO.

DATA SHEET



SPEC. NO.	ENERGY TO FTU IN.-LB./LB.	ENERGY TO FAILURE IN-LB/LB.
B-14X	107,100	114,400
B-15X	112,700	120,700
B-16X	108,700	115,800

STRAIN IN./IN.

.10

STRAIN RATE IN./IN./MIN.

(A) = .005

(B) = .05

2

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
B-14X	.0637	78,200	LONG.	800	AIR
B-15X	.0641	78,300	LONG.	800	AIR
B-16X	.0658	78,000	LONG.	800	AIR

(TYP.)

SEE PAGE 1-20 FOR NOTES

CALC	Arnie Hauge	5-9-61	REVISED	DATE	STRESS STRAIN CURVES INCONEL .127 GAGE SHEET
CHECK	CONNELL	5-9-61			BOEING AIRPLANE COMPANY
APR					
APR.					

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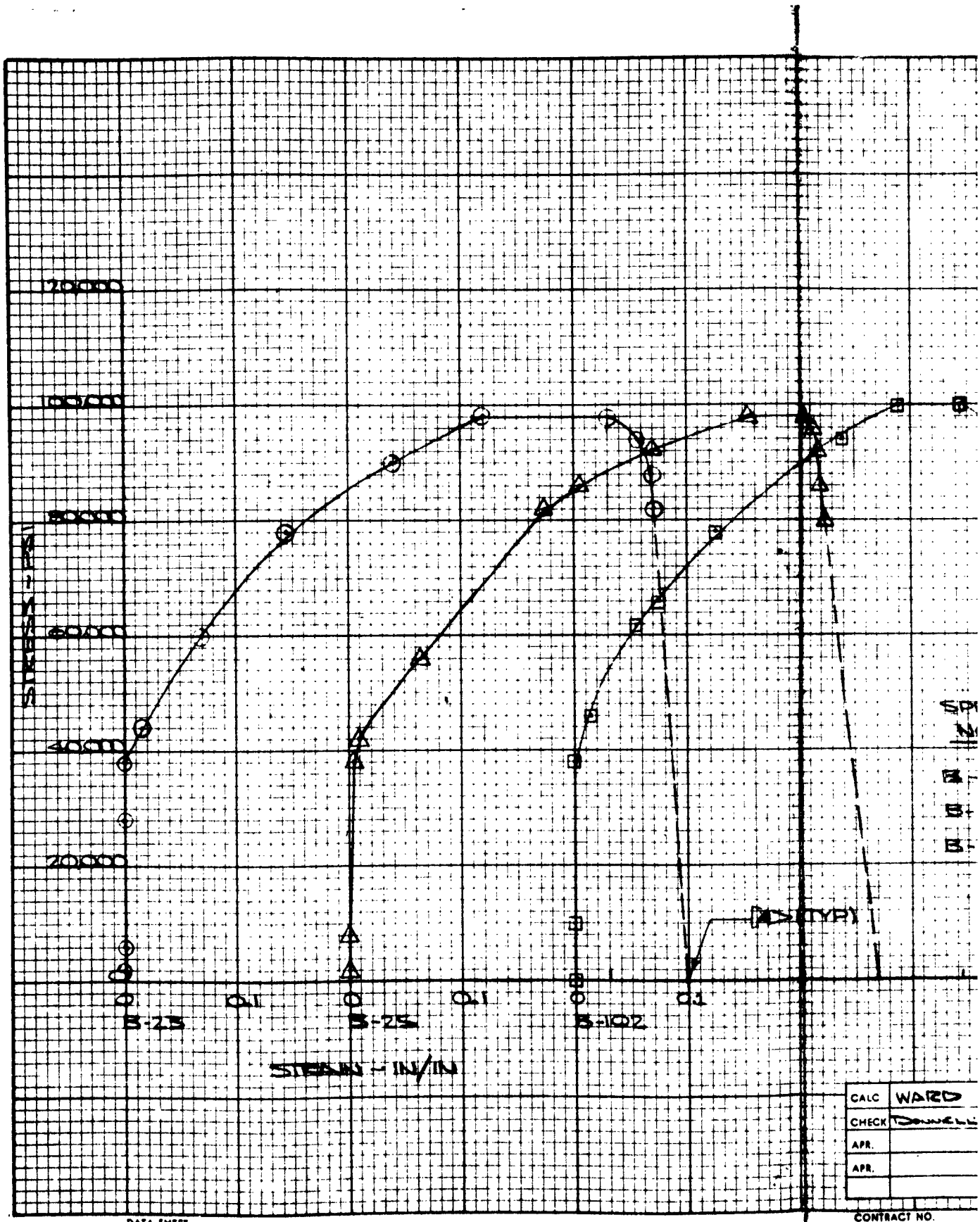
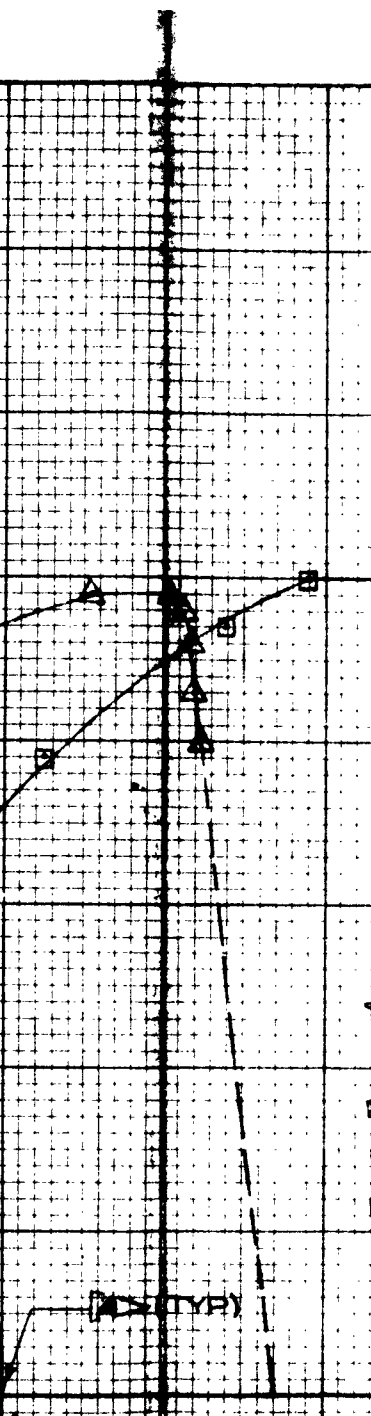
CONTRACT NO.



DATA SHEET

U3 4011 5000—REV. 7/68 (WAS SAC 360D)



SPEC. NO.	ENERGY TO ULT - IN-LB/LB	ENERGY TO FAILURE - IN-LB/LB
B-23	115,500	131,800
B-25	104,100	116,300
B-102	92,000	116,000

STRAIN IN/IN. — 0.1

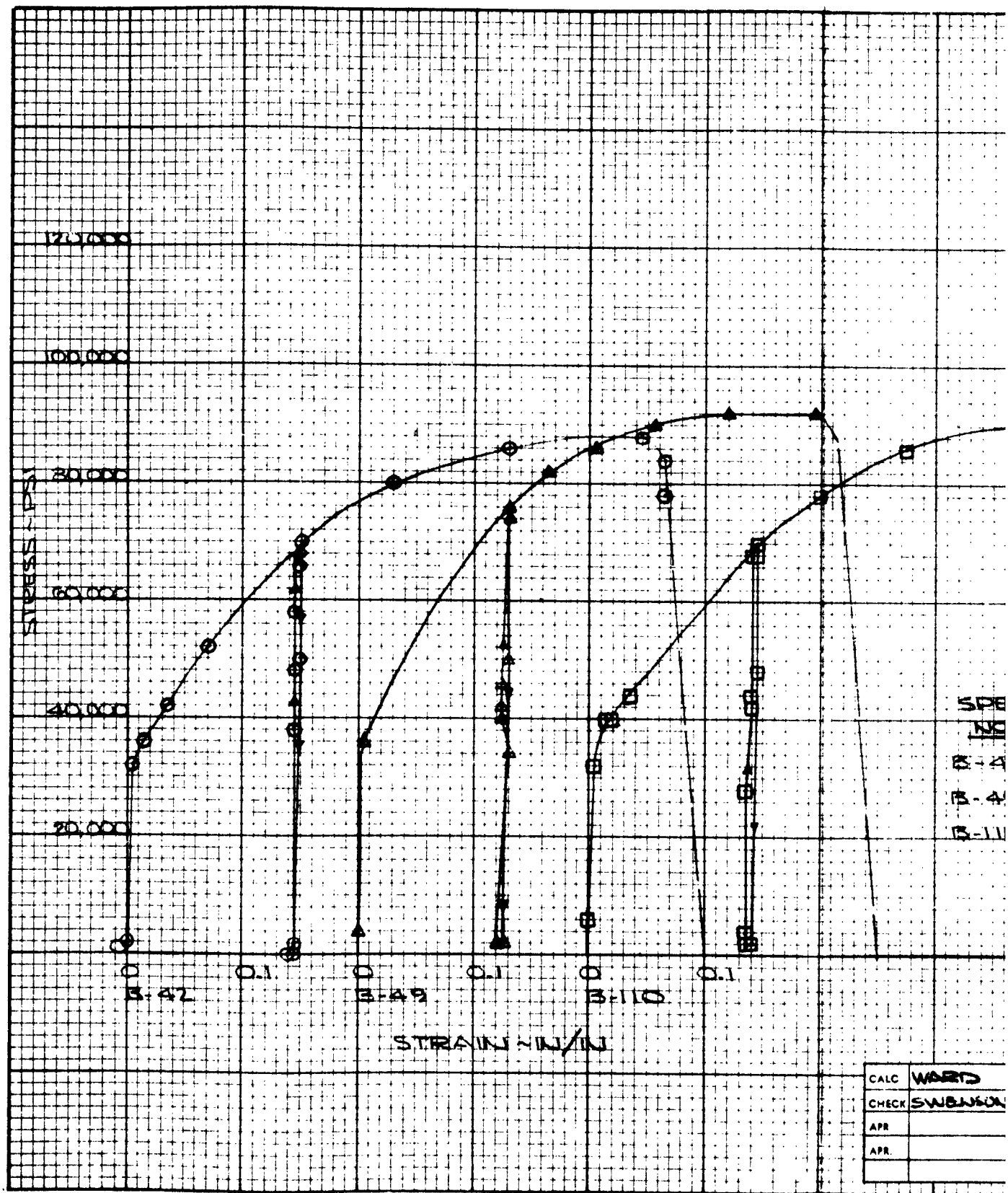
STRAIN RATE IN/IN/MIN. — 50

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP - °F	TEST ATMOS.
B-23	.06334	98,000	LONG.	-65	NITROGEN
B-25	.06371	98,000	LONG.	-65	NITROGEN
B-102	.06351	100,000	LONG.	-65	NITROGEN

* SEE PAGE 1-60 FOR NOTES *

			REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CALC	WARD	4-10-61				D2-80086
CHECK	DONNELL	4-12-61			BOEING AIRPLANE COMPANY	PAGE 1-61
APR.						
APR.						

CONTRACT NO.



DATA SHEET

CONTRACT NO.

CALC	WARD
CHECK	SWANSON
APR	
APR.	

2

SPEC. NO.	ENERGY TO FTU IN-LB/IN³	ENERGY TO FAILURE IN-LB/IN³
B-42	106,400	117,000
B-49	102,000	113,500
B-110	105,000	121,500

STRAIN IN/IN — 0.1

STRAIN RATE IN/IN/MIN — 50

SPEC. NO.	AREA - SQ. IN.	FTU - PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS
B-42	.0641	89,000	LONG.	R.T.	AIR
B-49	.0628	92,000	LONG.	R.T.	AIR
B-110	.0623	90,000	LONG.	R.T.	AIR

0.1

~SEE PAGE 1-20 FOR NOTES~

CALC	WARD	4-11-61	REVISED	DATE
CHECK	SWANSON	4-17-61		
APR				
APR				

STRESS - STRAIN CURVES
INCONEL
.127 GAGE SHEET

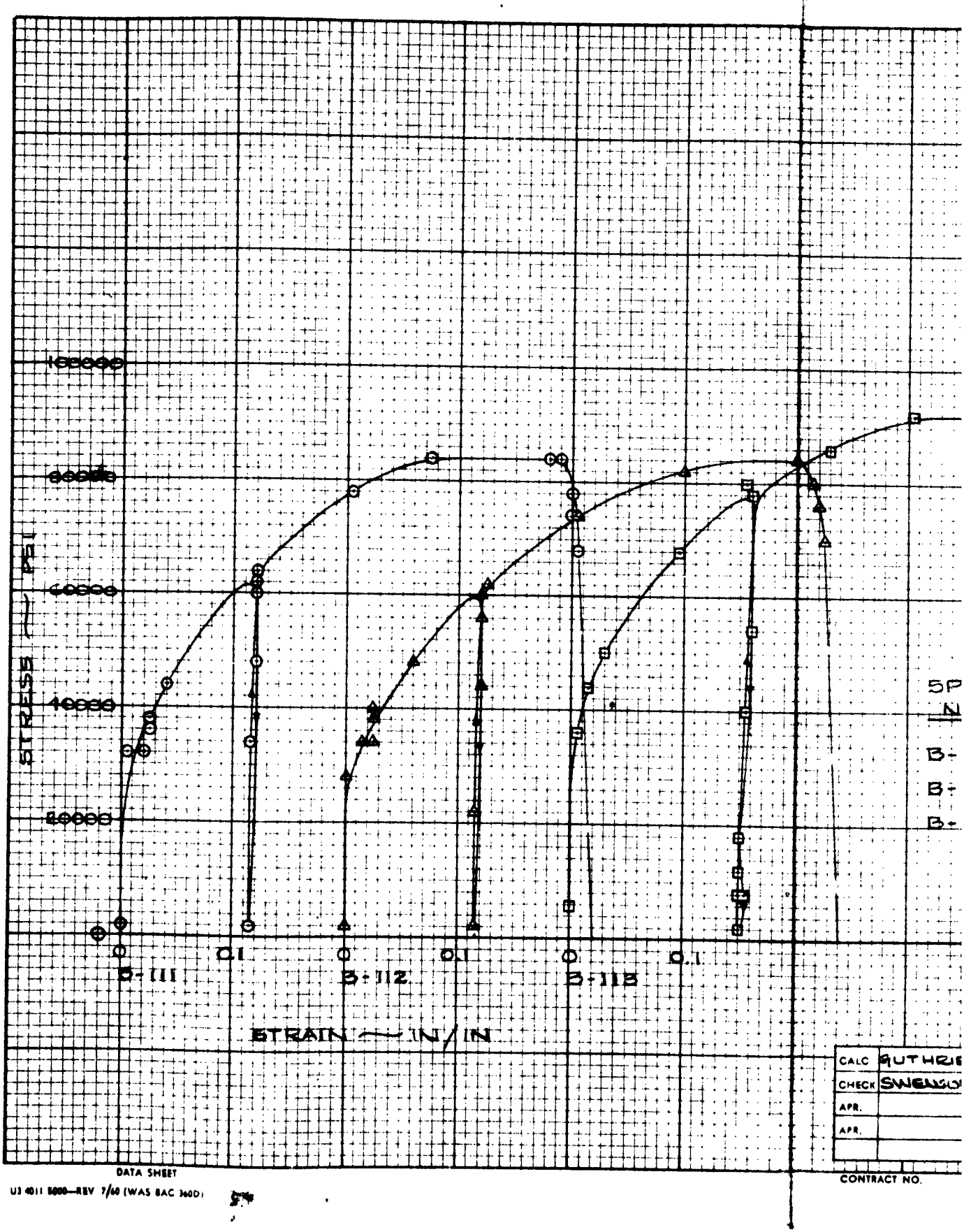
X-20A

D2-8008

BOEING AIRPLANE COMPANY

PAGE 1-42

CONTRACT NO.

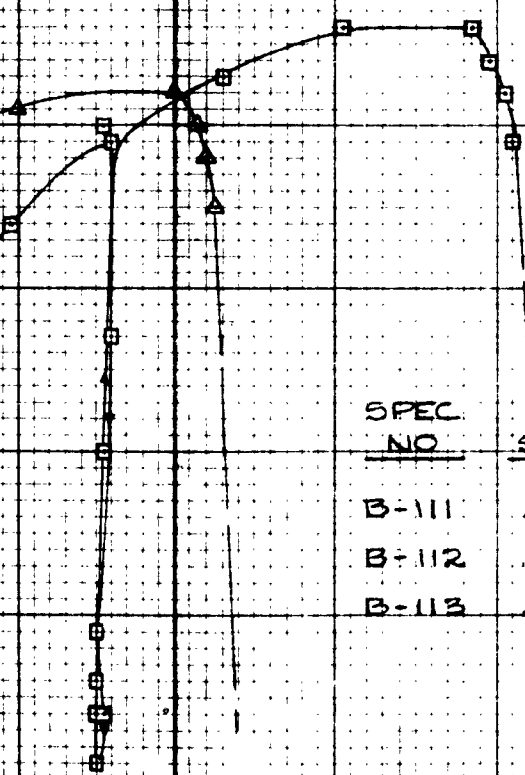


CALC	RUTHRIE
CHECK	SWENSON
APR.	
APR.	

CONTRACT NO.

DATA SHEET

U3 4011 5000—REV 7/60 (WAS BAC 360D)



SPEC NO	ENERGY TO ULT - IN-LB/LB	ENERGY TO FAIL - IN-LB/LB
B-111	89,600	95,400
B-112	90,300	98,700
B-113	98,500	105,500

STRAIN IN/IN — 0.1

STRAIN RATE IN/IN/MIN — 50

SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP - °F	TEST ATMOS
B-111	.0633	84000	LONG.	250	AIR
B-112	.0637	84000	LONG.	250	AIR
B-113	.0632	92000	LONG.	250	AIR

~SEE PAGE M FOR NOTES~

2

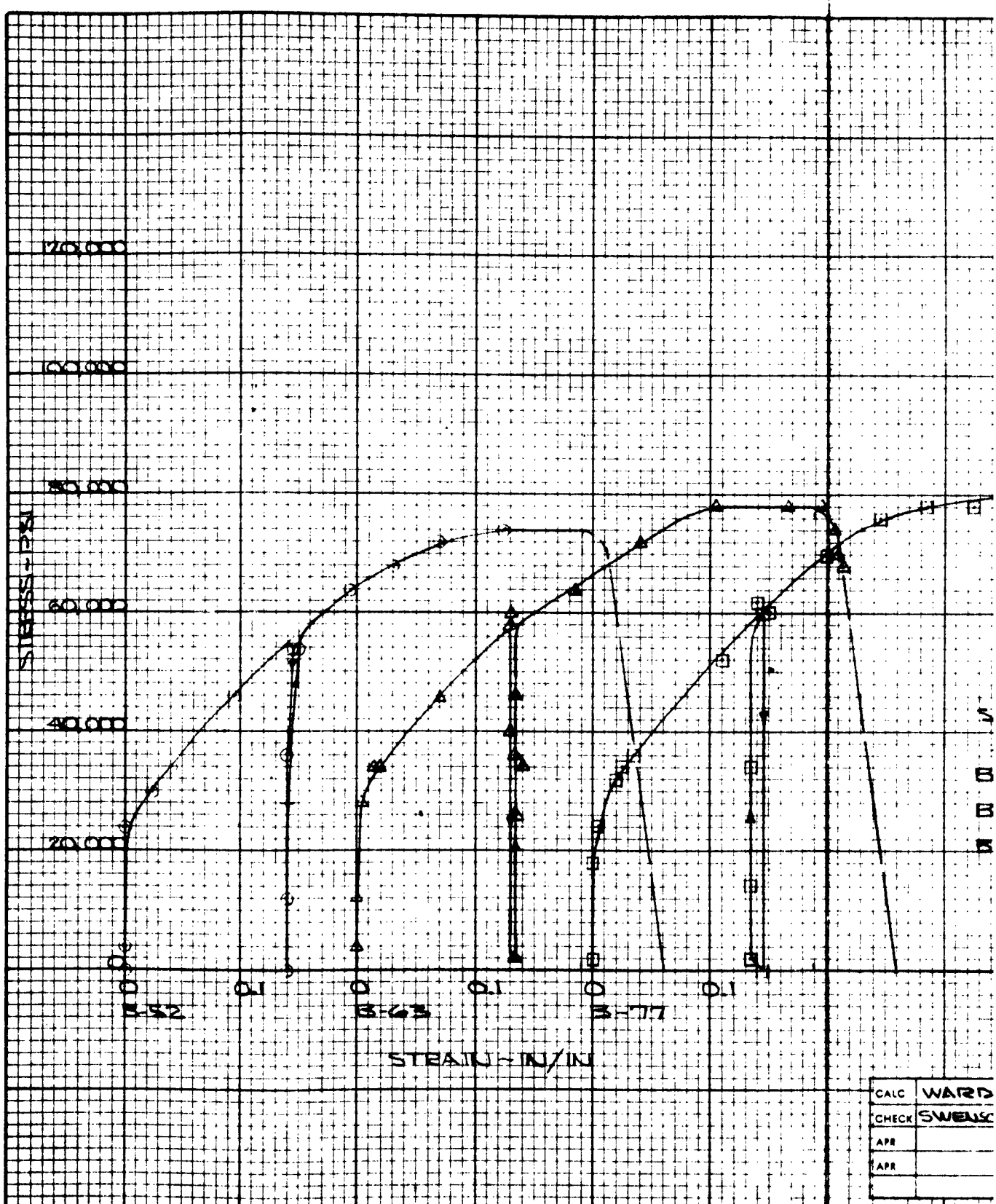
			REVISED	DATE
CALC	GUTHRIE	4-11-61		
CHECK	SWENSON	4-17-61		
APR.				
APR.				

STRESS - STRAIN CURVES
INCONEL
.127 GAGE SHEET

X-20A
D2-80086

BOEING AIRPLANE COMPANY

CONTRACT NO

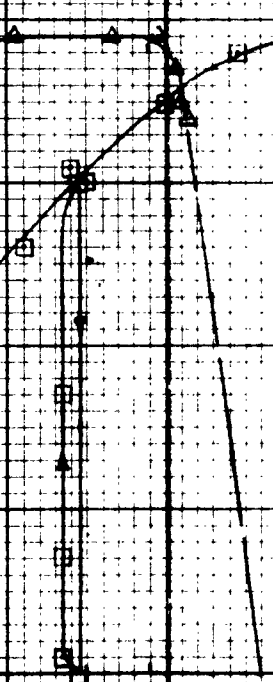


CALC	WARD
CHECK	SWELLS
APR	
APR	

DATA SHEET

CONTRACT NO.

US 4011 8000—REV. 7/60 (WAS BAC 3600)



SPEC. NO.	ENERGY TO FTU IN-LB/IN³	ENERGY TO FAILURE IN-LB/IN³
B-52	74,900	87,000
B-63	80,500	91,600
B-77	83,000	95,000

STRAIN IN/IN → 0.1

STRAIN RATE IN/IN/MIN → 50

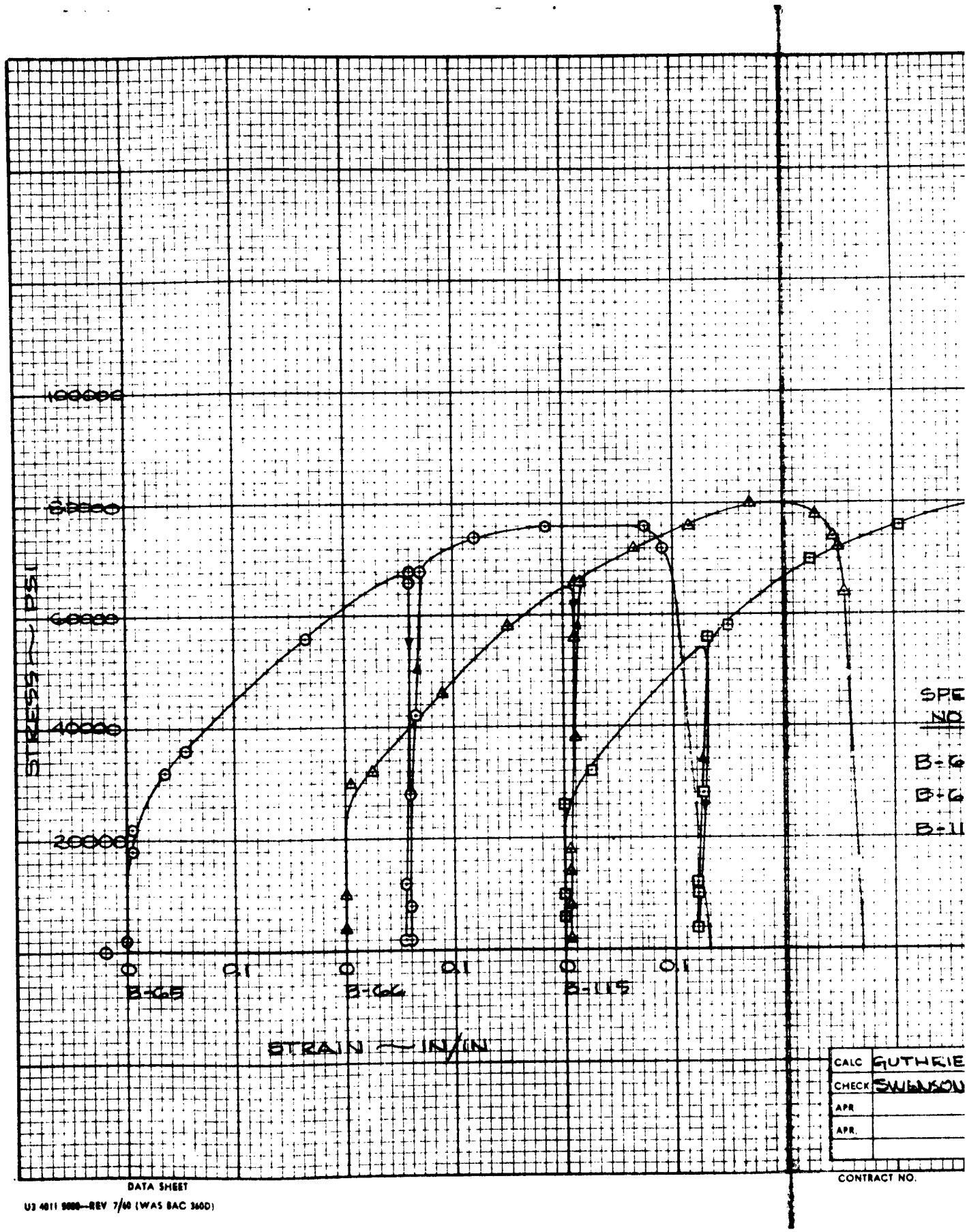
SPEC. NO.	AREA SQ. IN.	FTU KPSI	GRAIN DIRECTION	TEST TEMP-°F	TEST ATMOS.
B-52	.0638	74,000	LONG	600	AIR
B-63	.0635	78,000			
B-77	.0640	80,000	LONG	600	AIR

2

SEE PAGE I-20 FOR NOTES

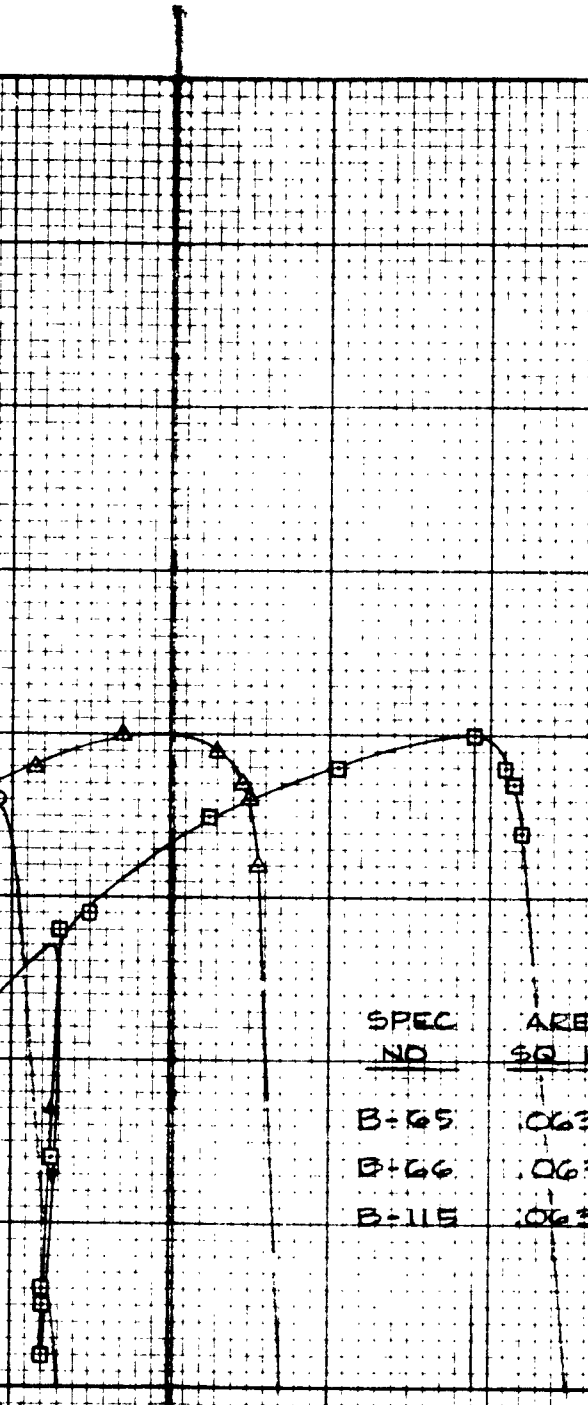
			REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CALC	WARD	4-4-61				D2-80086
CHECK	SWENSON	4-17-61				
APR					BOEING AIRPLANE COMPANY	PAGE 1-64
APR						

CONTRACT NO.



DATA SHEET

CONTRACT NO.



SPEC. NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
B65	95000	104,000
B66	88,300	96,400
B115	79,100	90,600

STRAIN IN/IN

STRAIN RATE IN/IN/MIN

0.1

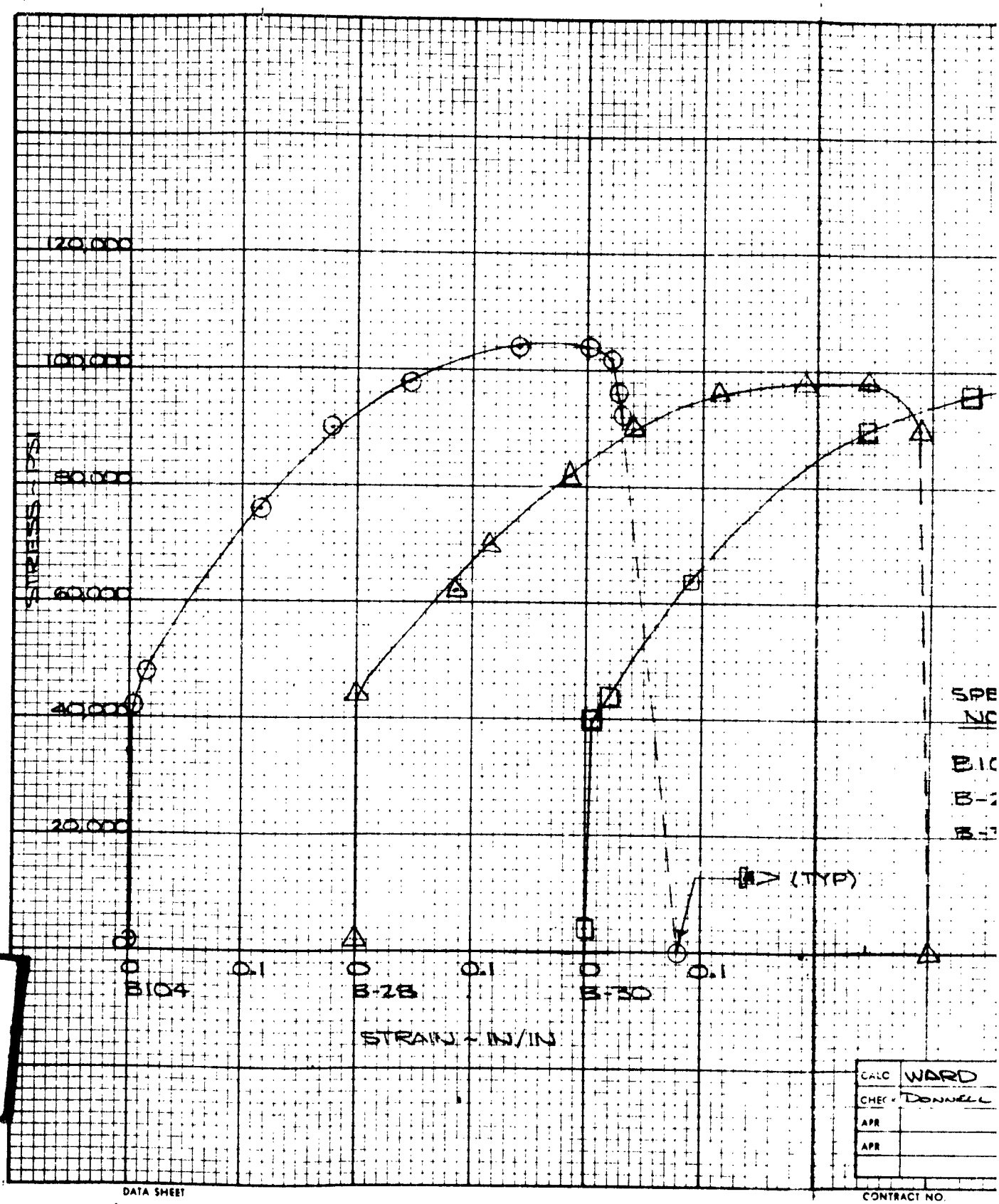
50

SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS
B-65	.0636	76000	LONG.	800	AIR
B-66	.0638	80000	LONG.	800	AIR
B-115	.0637	80000	LONG.	800	AIR

SEE PAGE 1-20 FOR NOTES

CALC	GUTHRIE	4.11.61	REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CHECK	SWENSON	4-17-61				D2-80086
APR					BOEING AIRPLANE COMPANY	PAGE 1-65
APR.						

CONTRACT NO.



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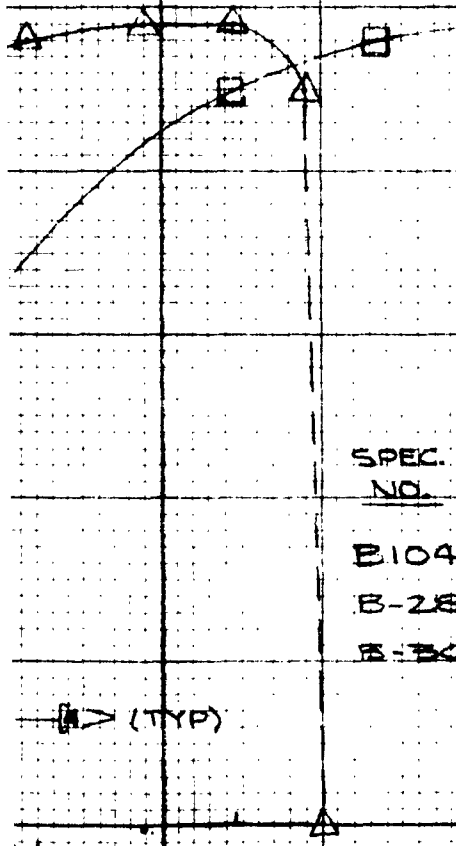
CALC WARD
CHEC DONNELL
APR
APR

DATA SHEET

CONTRACT NO.

2



SPEC. NO.	ENERGY TO ULT-IN-LB/IN³	ENERGY TO FAILURE-IN-LB/IN³
B104	118,900	131,600
B-28	120,900	136,500
B-30	116,300	130,000

STRAIN IN/IN — .01

STRAIN RATE IN/IN/MIN — 100

SPEC. NO.	AREA SQ.IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP-°F	TEST ATMOS.
B104	.0636	104,000	LONG	+65	NITROGEN
B-28	.0644	98,000	LONG.	+65	NITROGEN
B-30	.0644	98,000	LONG.	+65	NITROGEN

* SEE PAGE 1-70 FOR NOTES

			REVISED	DATE
CALC	WARD	3-30-1		
CHEC	DONNELL	4-12-61		
APR				
APR				

STRESS-STRAIN CURVES
INCONEL
.127 GAGE SHEET

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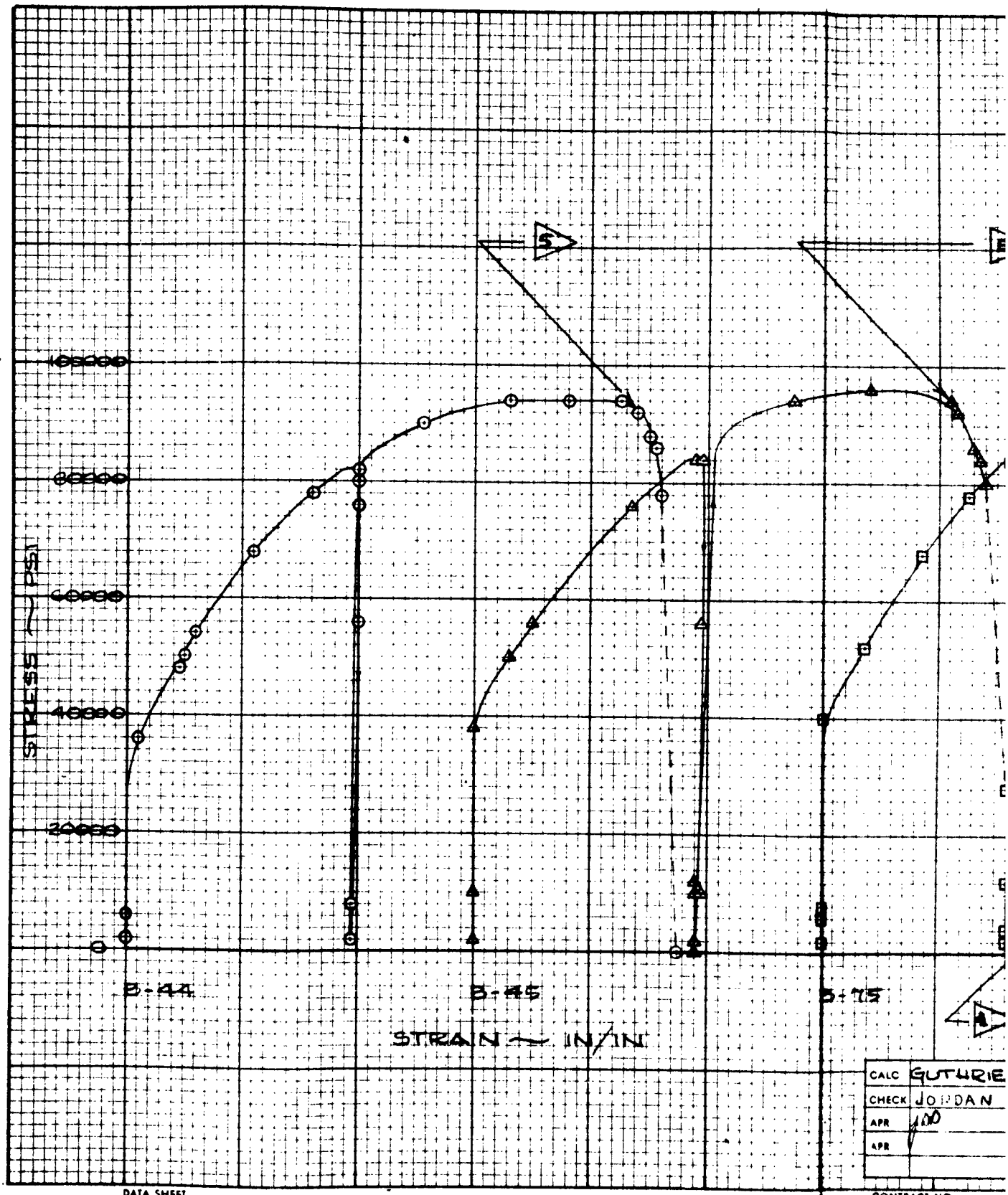
BOEING AIRPLANE COMPANY

CONTRACT NO



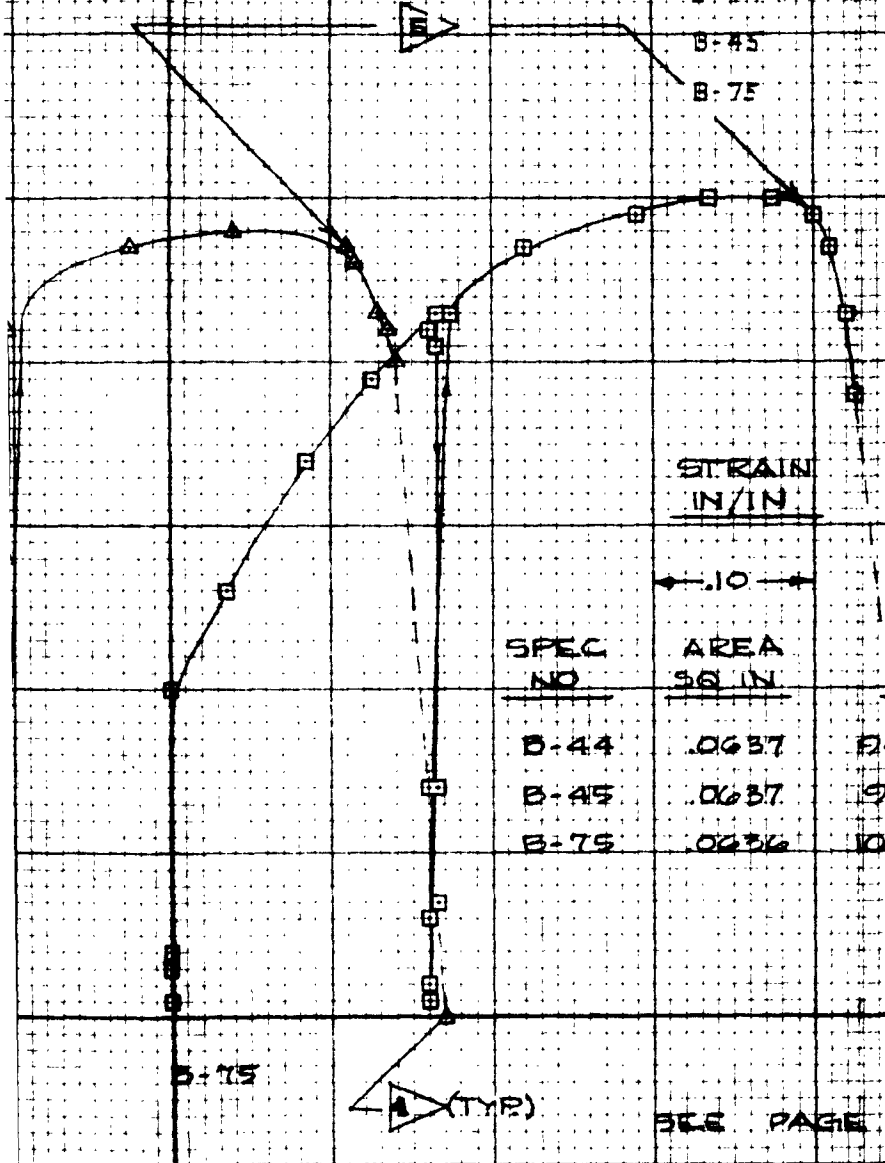
CALC	GUTHRIE
CHECK	JORDAN
APR	
APR	

DATA SHEET

CONTRACT NO

UB 4011 5000—REV 7/60 (WAS BAC 360D)

SPEC. NO.	ENERGY TO FTU ~ IN.-LB./I.B.	ENERGY TO FAIL ~ IN.-LB./I.B.
B-44	114,900	123,000
B-45	110,000	123,000
B-75	111,800	124,900



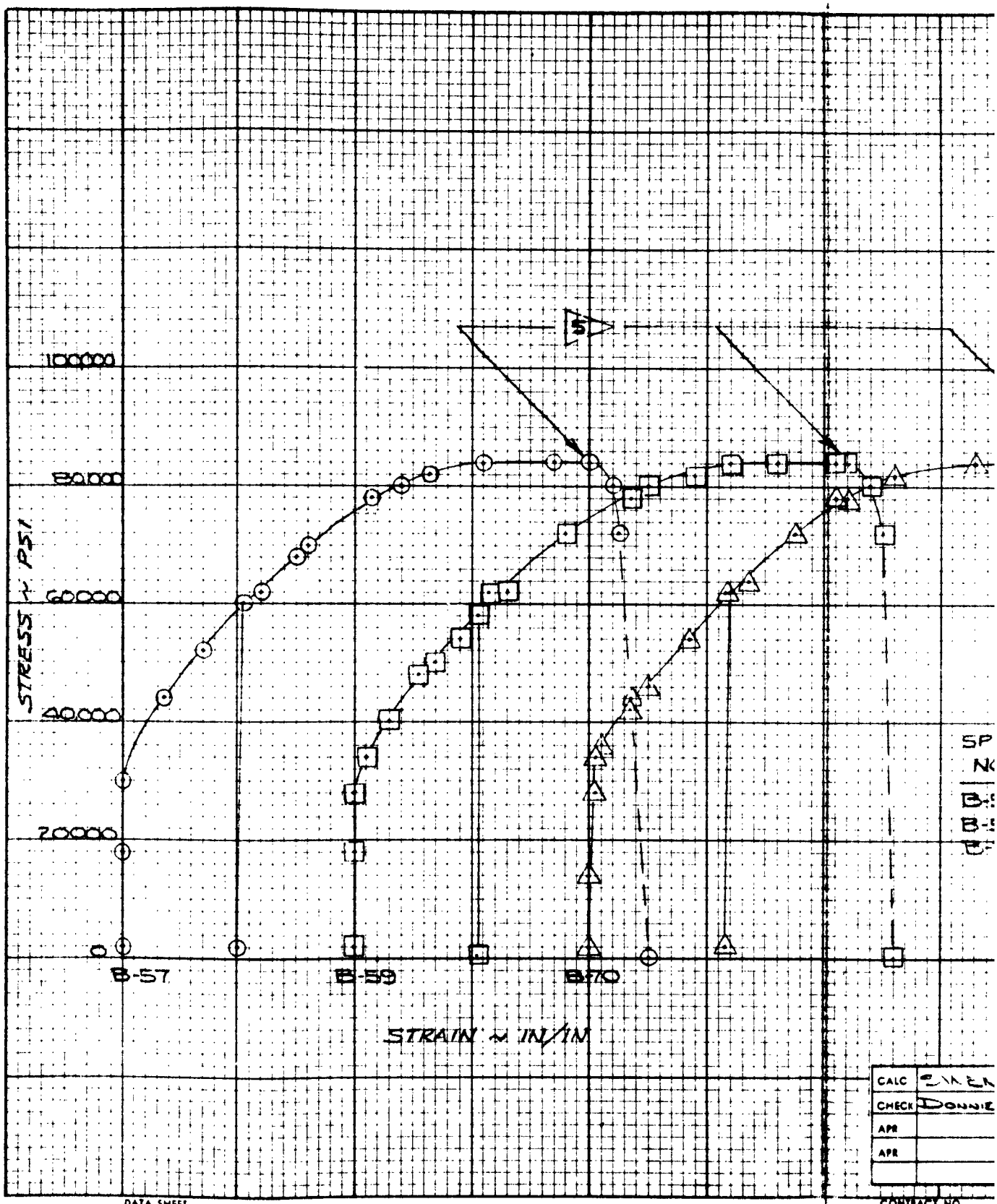
SPEC NO	STRAIN IN/IN .10 AREA SQ IN	STRAIN RATE IN/IN/MIN 100 FTU PSI	GRAIN DIRECTION	TEST TEMP ~ °F TZ TEST ATMOS
B-44	.0637	124000	LONG.	AIR
B-45	.0637	94000	LONG.	AIR
B-75	.0636	100000	LONG.	AIR

SEE PAGE 1-20 FOR NOTES

2

CALC	GUTHRIE	4.17.61	REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CHECK	JORDAN	4-28				D2-80086
APR	100	5-10-1			BOEING AIRPLANE COMPANY	PAGE 67
APR						

CONTRACT NO.



CALC
CHECK DONNIE
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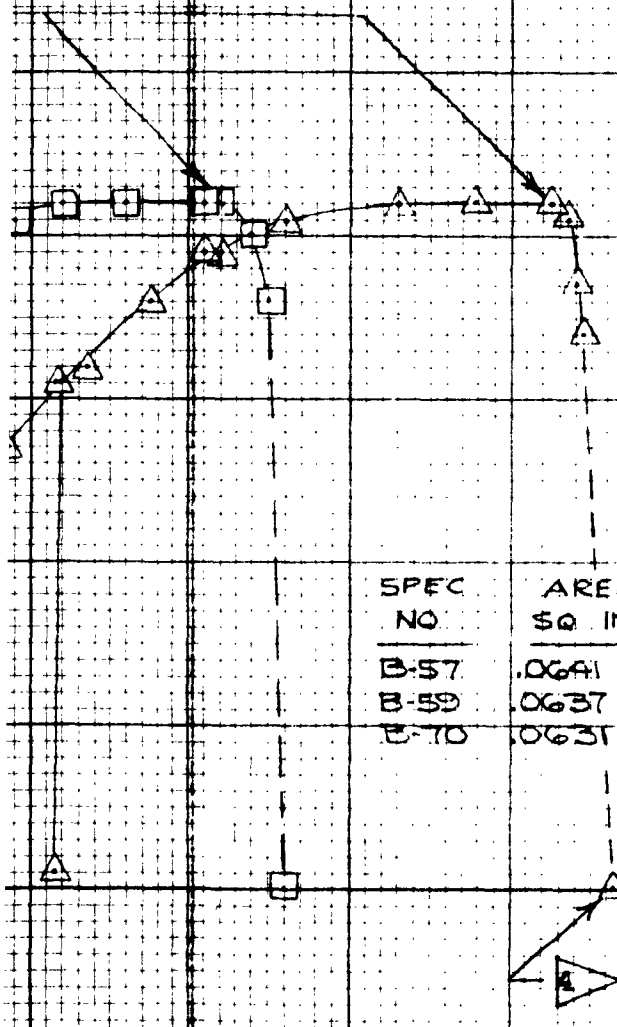
DATA SHEET

CONTRACT NO.

US 4011 5000—REV 7/60 (WAS BAC 360D)



SPEC NO.	ENERGY TO FTU IN-LB / LB	ENERGY TO FAILURE IN-LB / LB
B 57	93,100	103,000
B 59	97,700	107,300
B 70	95,700	107,500

STRAIN IN / IN	STRAIN RATE IN / IN / MIN
.10	100

SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS
B-57	.0641	84,000	LONG.	250	AIR
B-59	.0637	84,000	LONG.	250	AIR
B-70	.0631	84,000	LONG.	250	AIR

2

(TYP.)

SEE PAGE 1-20 FOR NOTES

			REVISED	DATE
CALC	E.M. EN	5-9-1		
CHECK	DONNELL	5-10-1		
APR		/		
APR				

STRESS STRAIN CURVES
INCONEL
.127 GAGE SHEET

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BOEING AIRPLANE COMPANY

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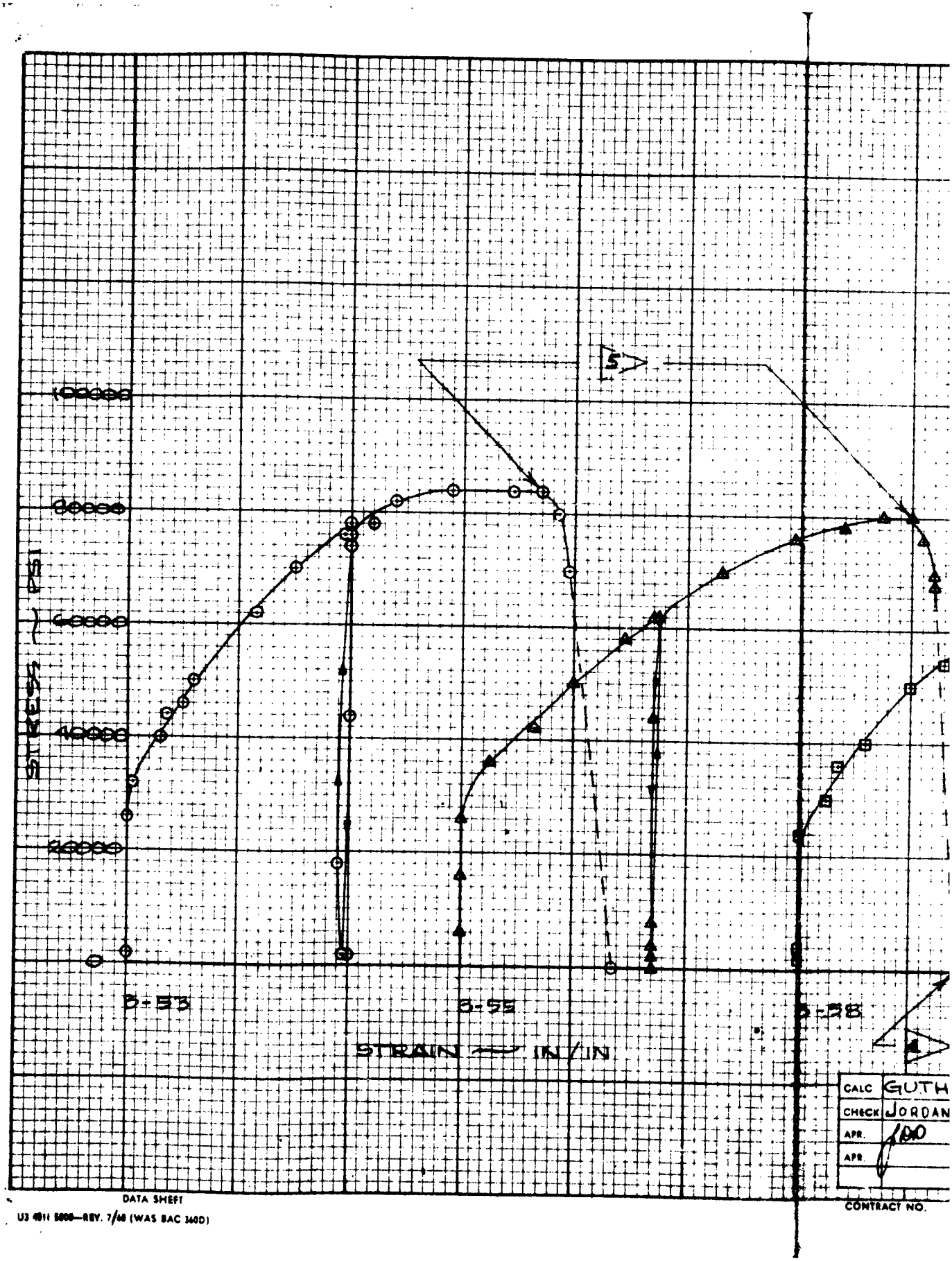
CONTRACT NO.



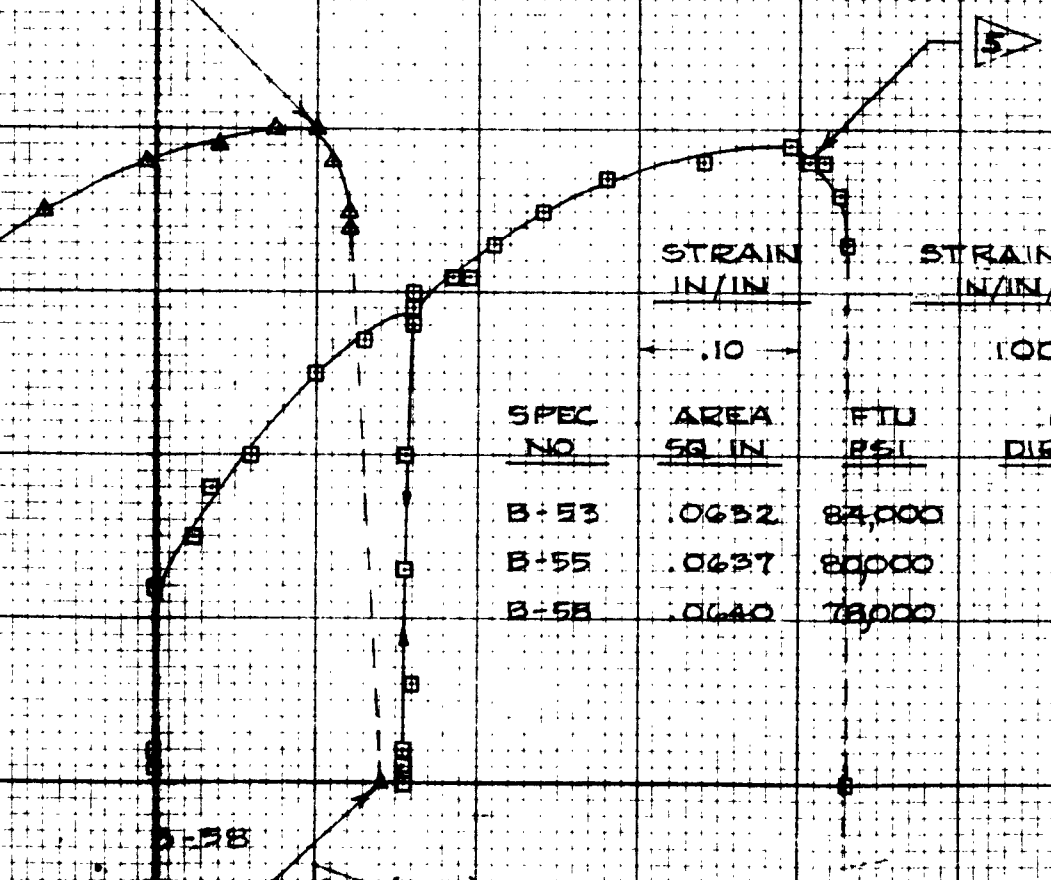
CALC GUTH
CHECK JORDAN
APR. 100
APR.

DATA SHEET

CONTRACT NO.

U3 4011 5008—REV. 7/68 (WAS BAC 360D)

SPEC. NO.	ENERGY TO FTU ~ IN-LB/LB	ENERGY TO FAIL ~ IN-LB/LB
B-53	88,500	96,500
B-55	85,600	90,400
B-58	82,500	88,400



STRAIN IN/IN	STRAIN RATE IN/IN/MIN	TEST TEMP ~ °F
.10	100	600

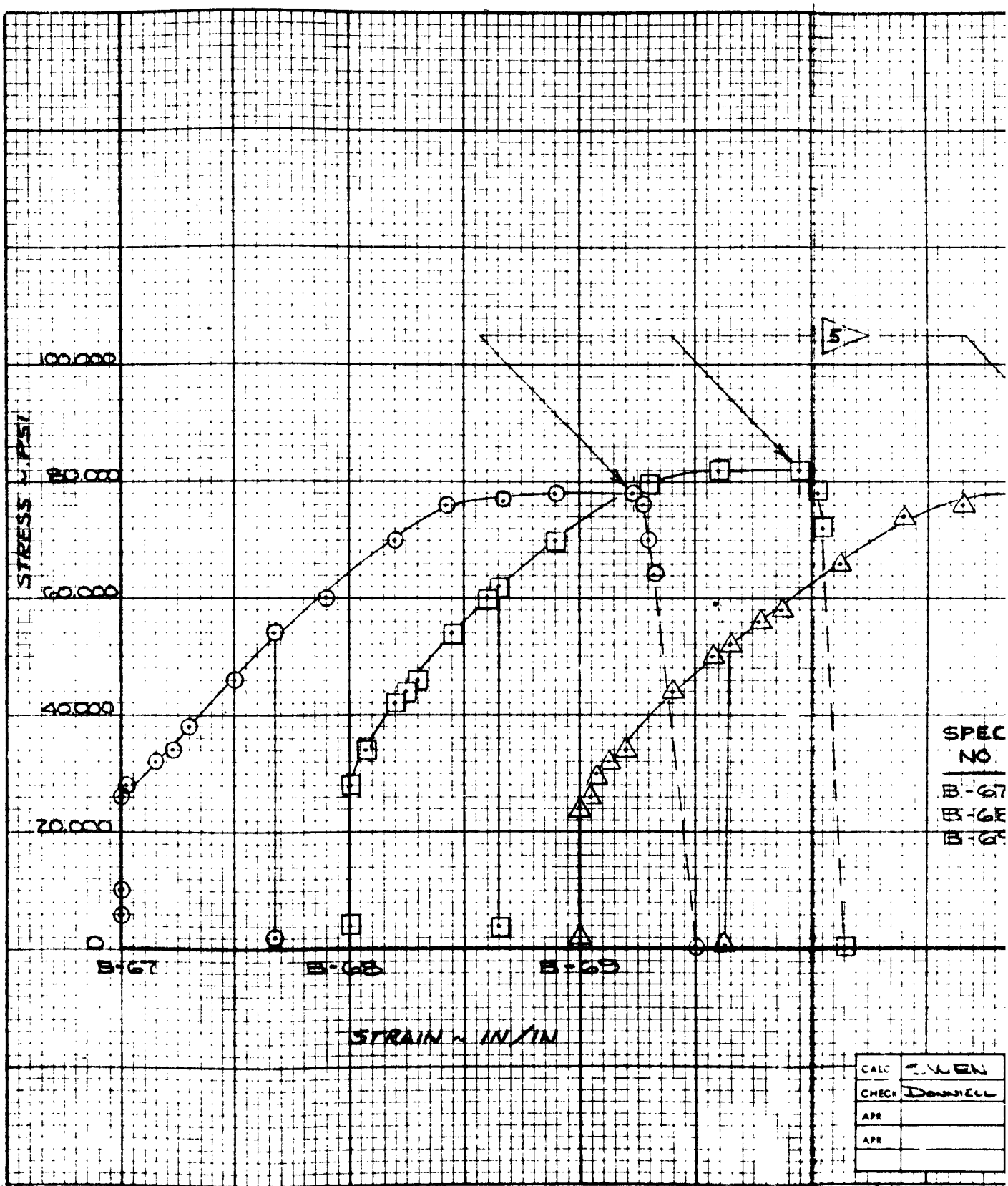
SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST ATMOS
B-53	.0652	84,000	LONG.	AIR
B-55	.0637	80,000	LONG.	AIR
B-58	.0640	78,000	LONG.	AIR

SEE PAGE 120 FOR NOTES

2

			REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CALC	GUTHRIE	4.19.1				D2-8008L
CHECK	JORDAN	4-28			BOEING AIRPLANE COMPANY	PAGE 1-69
APR.	[illegible]	5-10-1				
APR.						

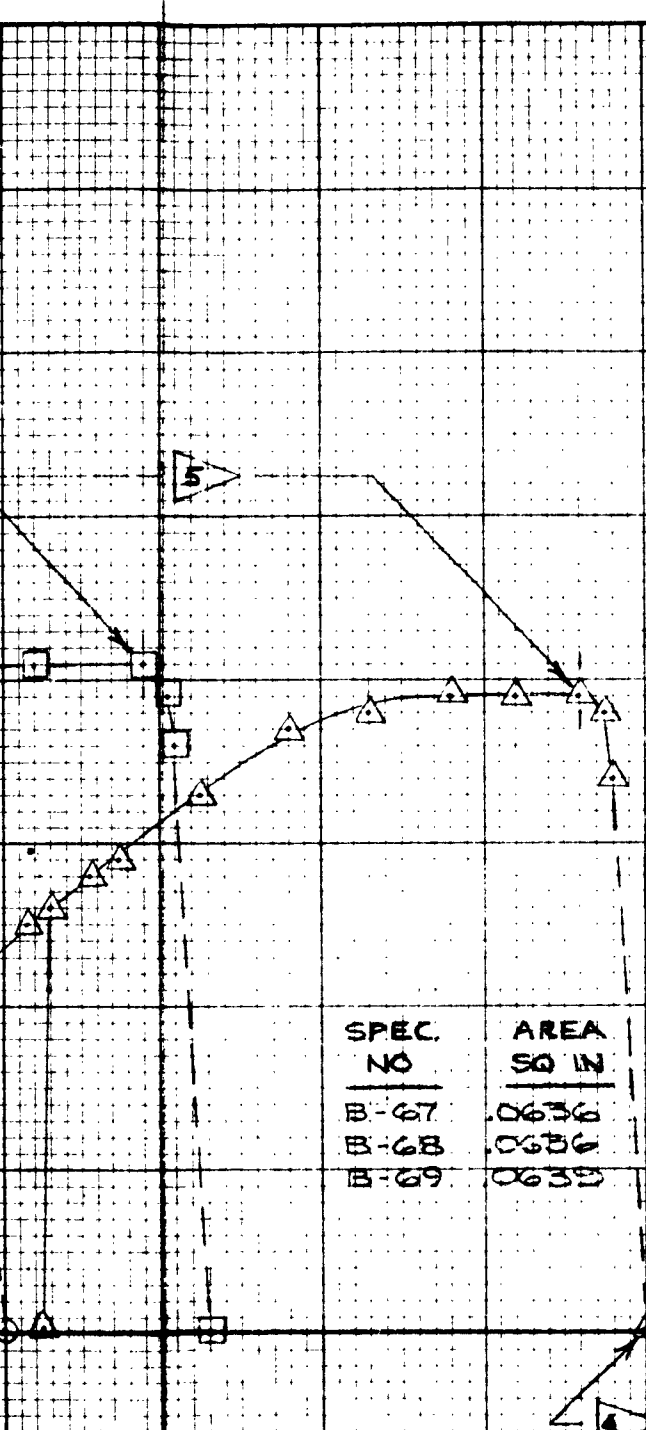
CONTRACT NO.



DATA SHEET

CONTRACT NO.

U3 4011 5000—REV 7/60 (WAS BAC 360D)



SPEC. NO.	ENERGY TO FTU IN-LB / LB	ENERGY TO FAILURE IN-LB / LB
B-67	191,600	100,500
B-68	86,800	94,300
B-69	95,000	102,500

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	100

SPEC. NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
B-67	.0636	78,000	LONG.	800	AIR
B-68	.0636	82,000	LONG.	800	AIR
B-69	.0635	78,000	LONG.	800	AIR

SEE PAGE 1-20 FOR NOTES

2

			REVISED	DATE
CALC	[illegible]	5-9-61		
CHECK	Donnell	5-10-1		
APR		✓		
APR				

STRESS STRAIN CURVES
INCONEL
.127 GAGE SHEET

BOEING AIRPLANE COMPANY

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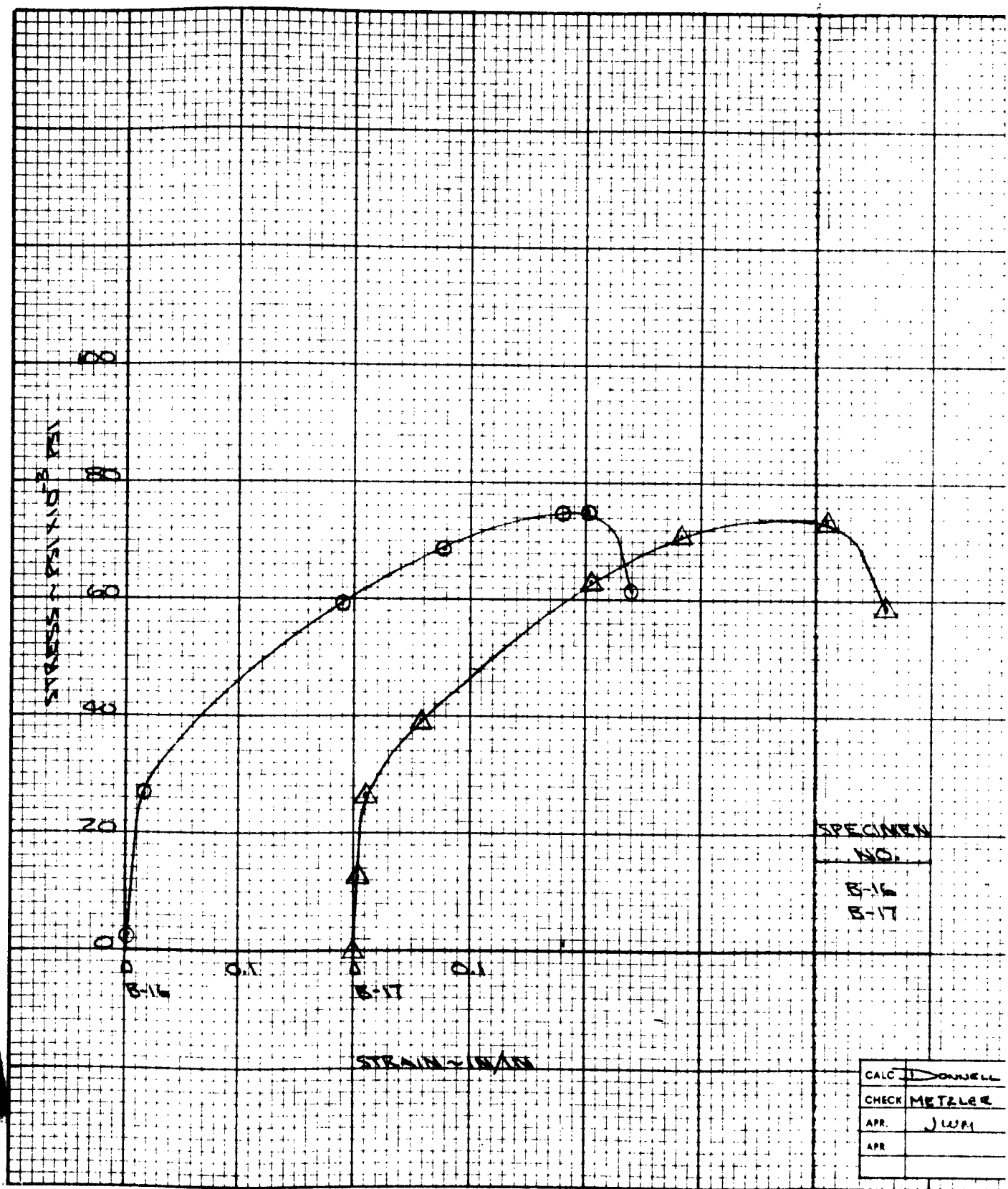
D2-80086
PAGE 1-70

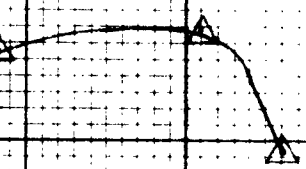
CONTRACT NO.



CALC	DONNELL
CHECK	METZLER
APR.	JWM
APR	

DATA SHEET

CONTRACT NO.



SPEC NO	ENERGY TO ULT IN-LB/LB	ENERGY TO FAIL IN-LB/LB
B-16	74,000	85,400
B-17	78,600	86,700

STRAIN ~IN/IN

← 0.1 →

STRAIN RATE ~IN/IN/MIN

180 TYP

2

SPECIMEN NO.	AREA ~SQ IN.	ETU ~PSI	GRAIN DIRECTION	TEST TEMP (°F)	TEST ATMOS.
B-16	.0646	75,670	LONG.	600°	AIR
B-17	.0643	73,960	LONG.	600°	AIR

			REVISED	DATE
CALC	DONNELL	1-28-1		
CHECK	METZLER	1-28-1		
APR.	J WH	1/29/		
APR				

STRESS-STRAIN CURVES
INCONEL
.127 GAGE SHEET

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BOEING AIRPLANE COMPANY

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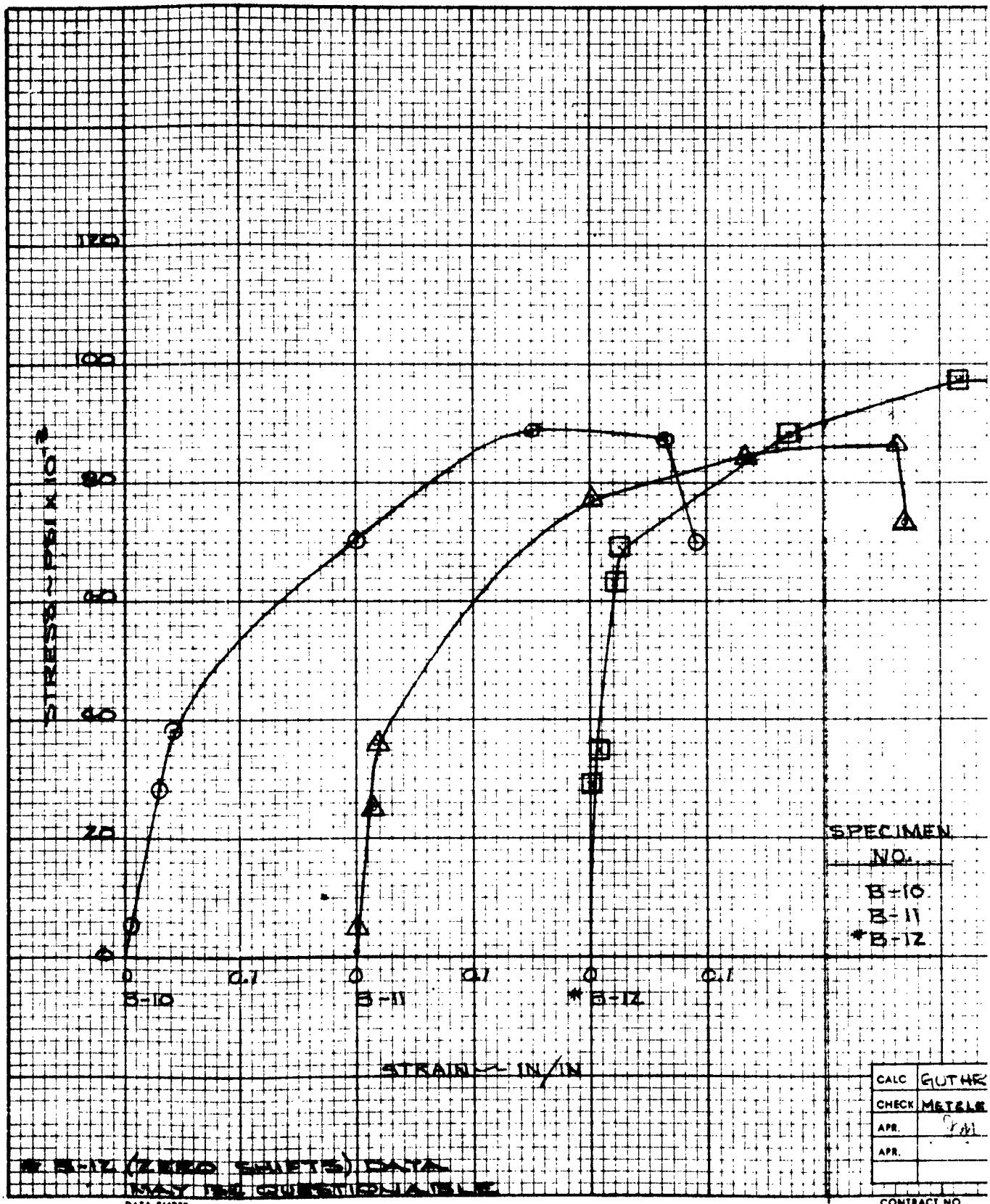
CONTRACT NO.



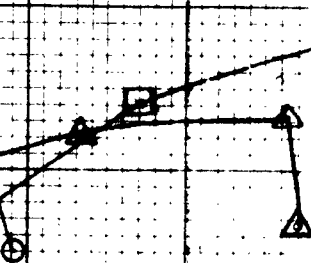
* B-12 (ZERO SHIFTS) DATA MAY BE QUESTIONABLE

CALC	GUTHR
CHECK	METCLF
APR.	
APR.	

DATA SHEET

CONTRACT NO

U3 4011 5000—REV. 7/60 (WAS BAC 3680)



SPEC NO.	ENERGY TO ULT. IN-LB/IN	ENERGY TO FAIL, IN-LB/IN
B-10	106,700	113,200
B-11	110,000	111,600
*B-12	128,000	128,200

STRAIN ± IN/IN

← .01 →

STRAIN RATE ± IN/IN/MIN

190 (TYP.)

2

SPECIMEN NO.	AREA ± SQ. IN.	FTU ± PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
B-10	.0696	88,500	LONG.	72	AIR
B-11	.0641	86,100	LONG.	72	AIR
*B-12	.0640	97,300	LONG.	72	AIR

.01

			REVISED	DATE
CALC	GUTHRIE	1-27-61		
CHECK	METZLER	1-28-61		
APR.	[illegible]	1-29-61		
APR.				

STRESS – STRAIN CURVES
INCONEL
.127 GAGE SHEET

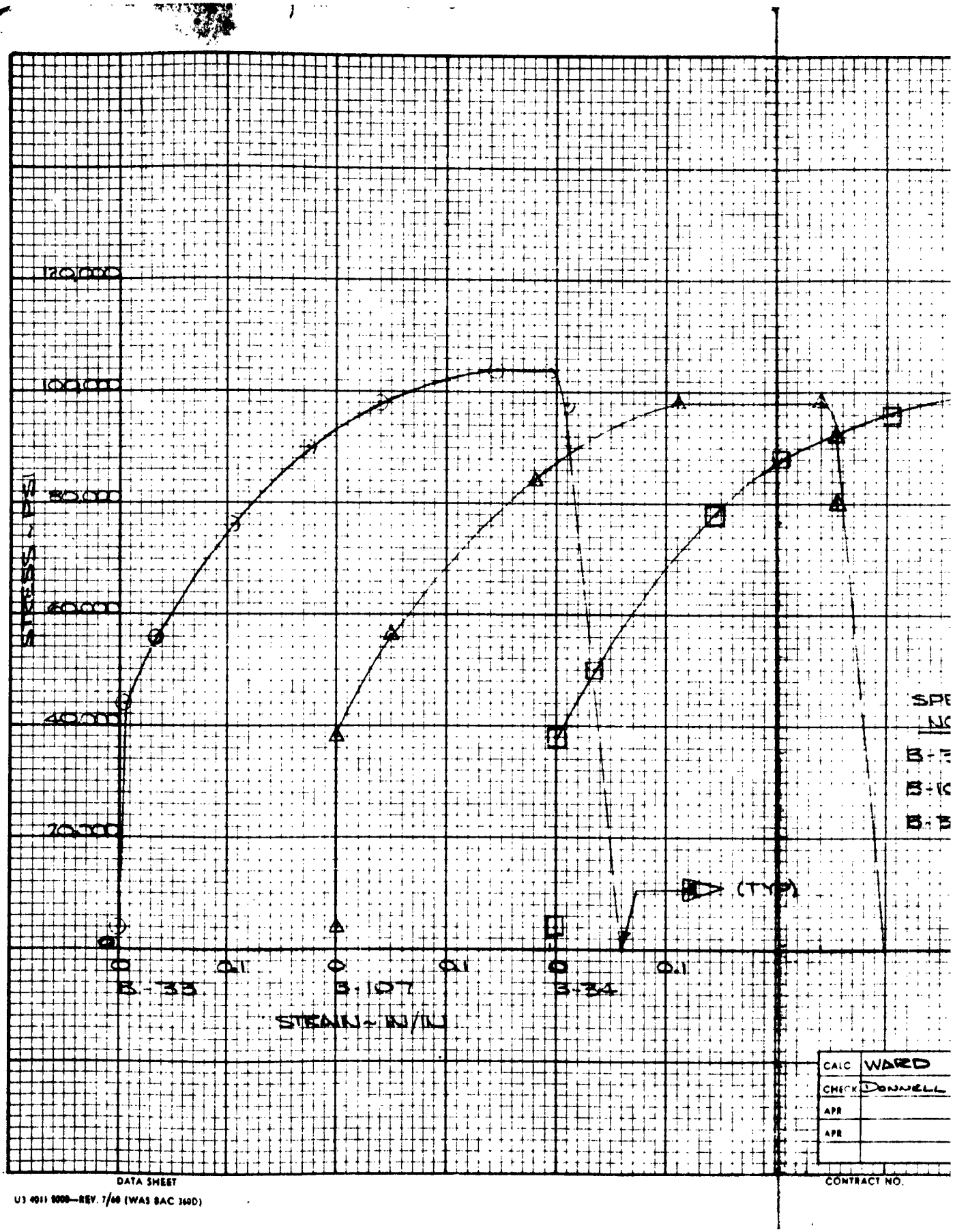
X-20A

D2-80086

BOEING AIRPLANE COMPANY

PAGE 1-72

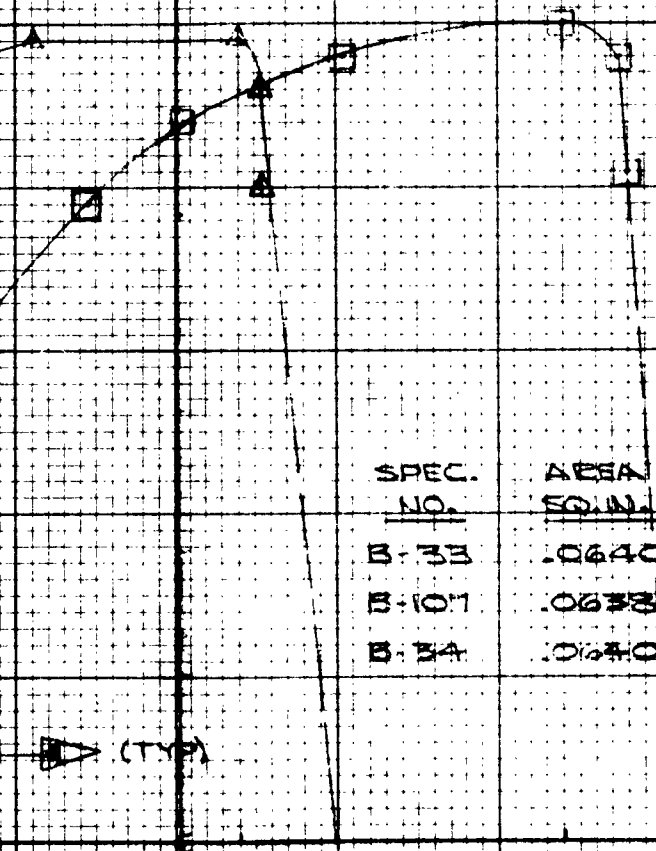
CONTRACT NO



DATA SHEET

CONTRACT NO.

2



SPEC. NO.	ENERGY TO ULT. - IN-LB/LB	ENERGY TO RUPTURE - IN-LB/LB
B-33	112,100	125,300
B-107	120,700	132,000
B-34	120,500	136,800

STRAIN IN/IN: ←0.1→

STRAIN RATE IN/IN/MIN: .200

SPEC. NO.	AREA SQ.IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP. °F	TEST ATMOS.
B-33	.0640	104,000	LONG.	+65	NITROGEN
B-107	.0638	98,000	LONG.	+65	NITROGEN
B-34	.0640	100,000	LONG.	+65	NITROGEN

- SEE PAGE 1-20 FOR NOTES

CALC	WARD	3-28-1	REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET
CHECK	DONNELL	4-12-61			
APR					
APR					

X-20A

D2-80086

BOEING AIRPLANE COMPANY

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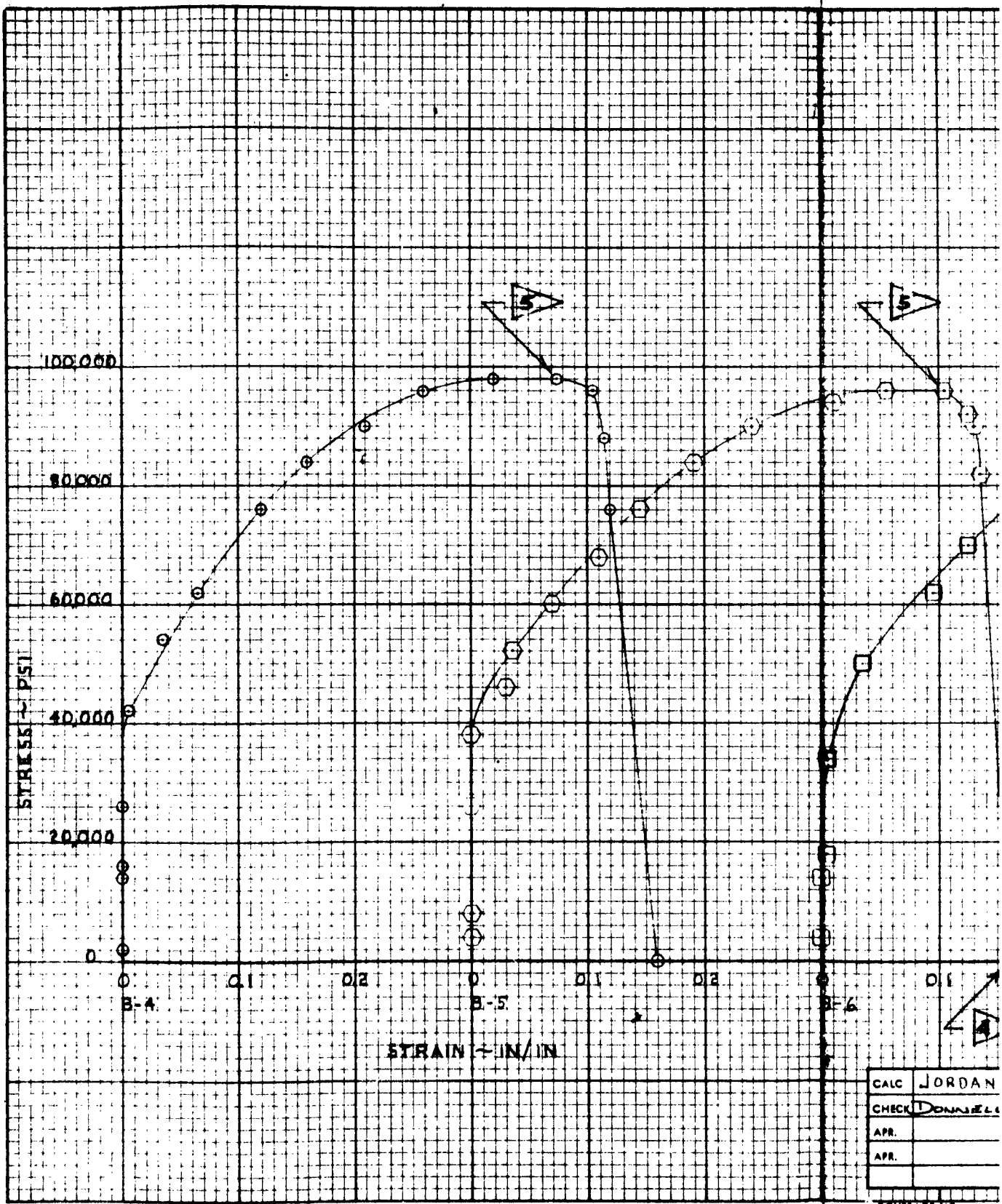
CONTRACT NO.



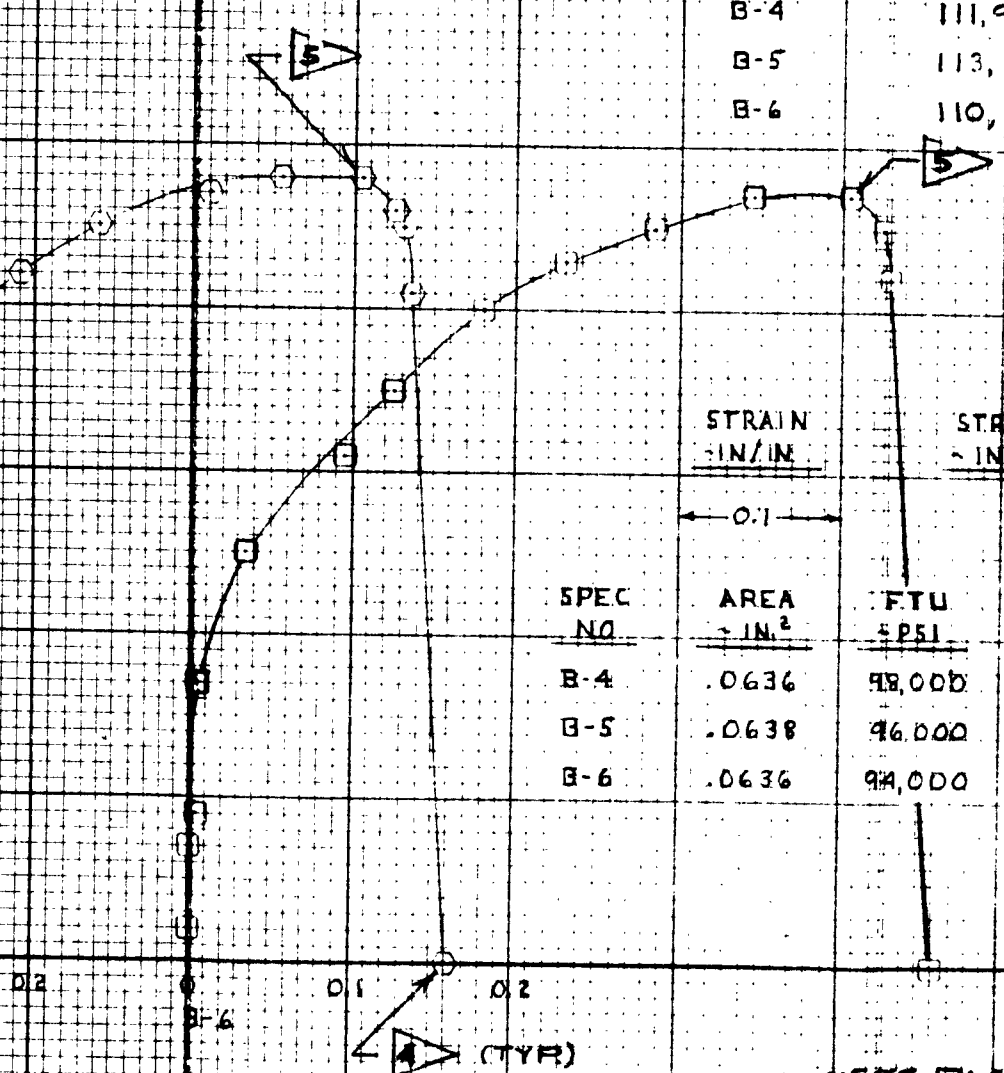
CALC	JORDAN
CHECK	DONNELL
APR.	
APR.	

CONTRACT NO.

DATA SHEET

US 4811 5000—REV. 7/60 (WAS BAC 360D)

SPEC. NO.	ENERGY TO ULT. ~ IN-LB/LB	ENERGY TO FAIL. ~ IN-LB/LB
B-4	111,900	121,000
B-5	113,700	120,000
B-6	110,000	116,000



STRAIN ~ IN/IN	STRAIN RATE ~ IN/IN/MIN	TEST TEMP ~ °F
0.1	200	72

SPEC NO	AREA ~ IN.^{2}	FTU ~ PSI	GRAIN DIRECTION	TEST ATMOS.
B-4	.0636	98,000	LONG.	AIR
B-5	.0638	96,000	LONG.	AIR
B-6	.0636	94,000	LONG.	AIR

2

~SEE PAGE 00 FOR NOTES~

			REVISED	DATE
CALC	JORDAN	4-28		
CHECK	DONNELL	5-1-61		
APR.				
APR.				

STRESS - STRAIN CURVES
INCONEL
.127 GAGE SHEET

X-20A
D2-80086

BOEING AIRPLANE COMPANY

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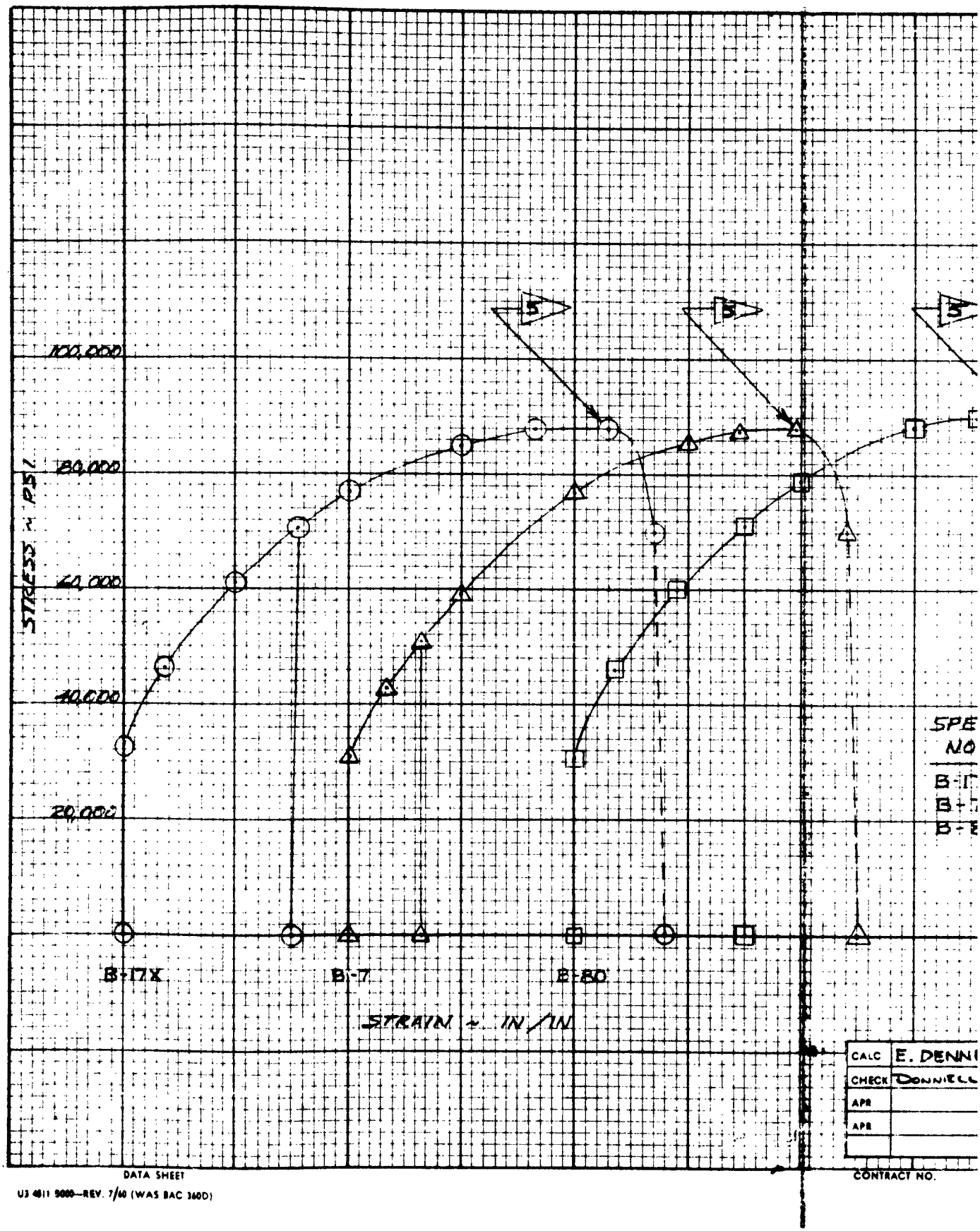
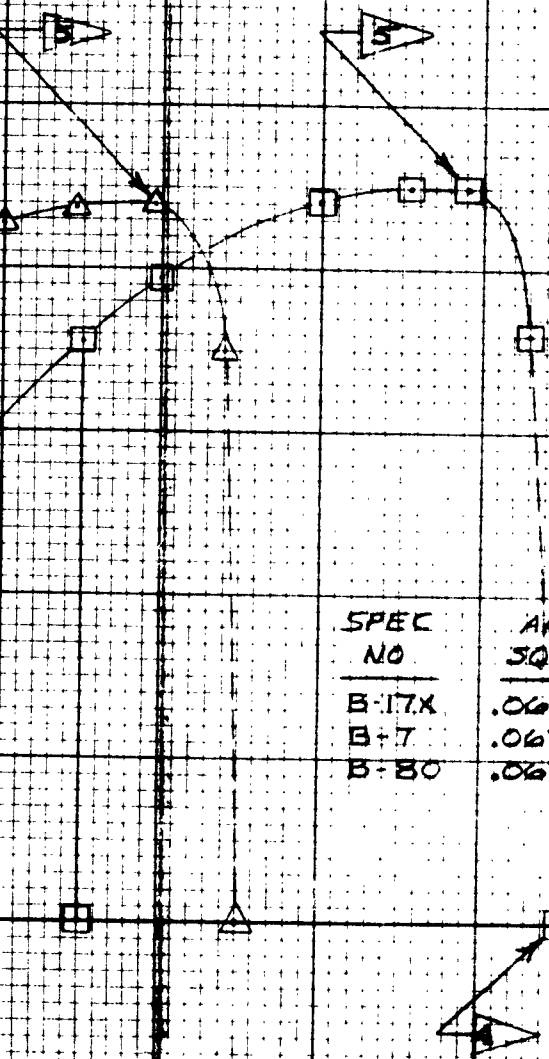
CONTRACT NO.



DATA SHEET

CONTRACT NO.



SPEC NO	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
B-17X	109,000	116,300
B-7	92,700	106,700
B-80	99,600	108,200

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	200

SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
B-17X	.0622	88,000	LONG.	250	AIR
B-7	.0633	88,000	LONG.	250	AIR
B-80	.0637	90,000	LONG.	250	AIR

SEE PAGE HD FOR NOTES

2

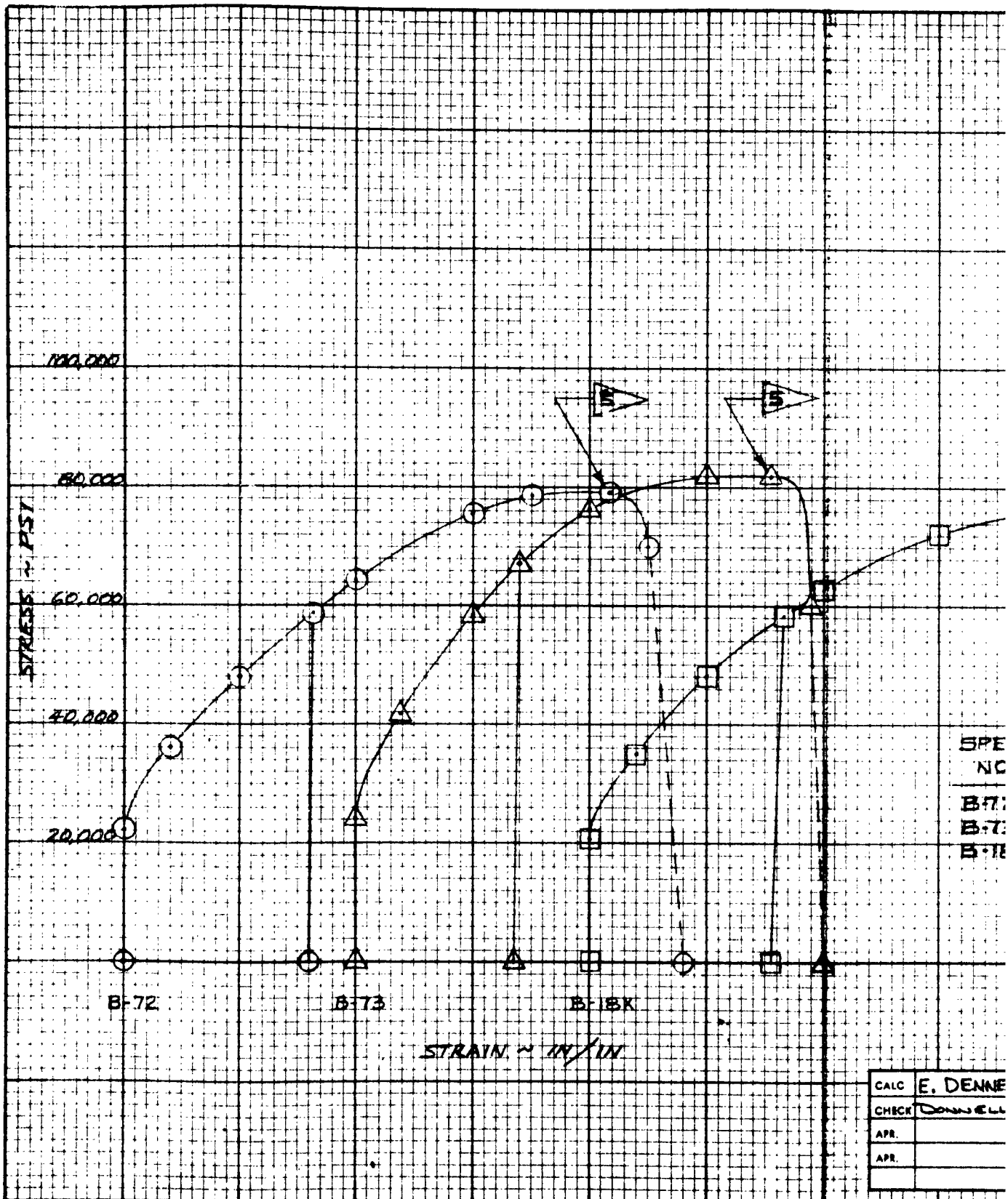
			REVISED	DATE
CALC	E. DENNEY	5/7/61		
CHECK	DONNELL	5-10-1		
APR				
APR				

STRESS STRAIN CURVES
INCONEL
.127 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A
D2-80084
PAGE 1-75

CONTRACT NO.



SPE
NC
B-7
B-7
B-1

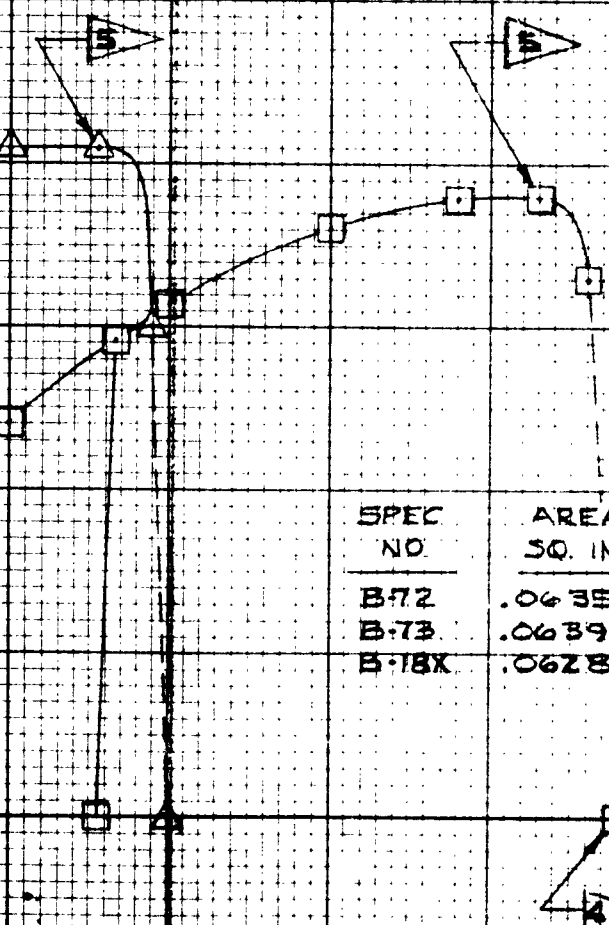
CALC	E. DENNE
CHECK	CONNELL
APR.	
APR.	

DATA SHEET

CONTRACT NO.

U3 4011 5000--REV 7/60 (WAS BAC 560D)

SPEC NO.	ENERGY TO FTU IN-LB / LB	ENERGY TO FAILURE IN-LB / LB
B-72	84,900	97,400
B-73	80,100	88,900
B-18X	85,600	95,500



2

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
.10	200

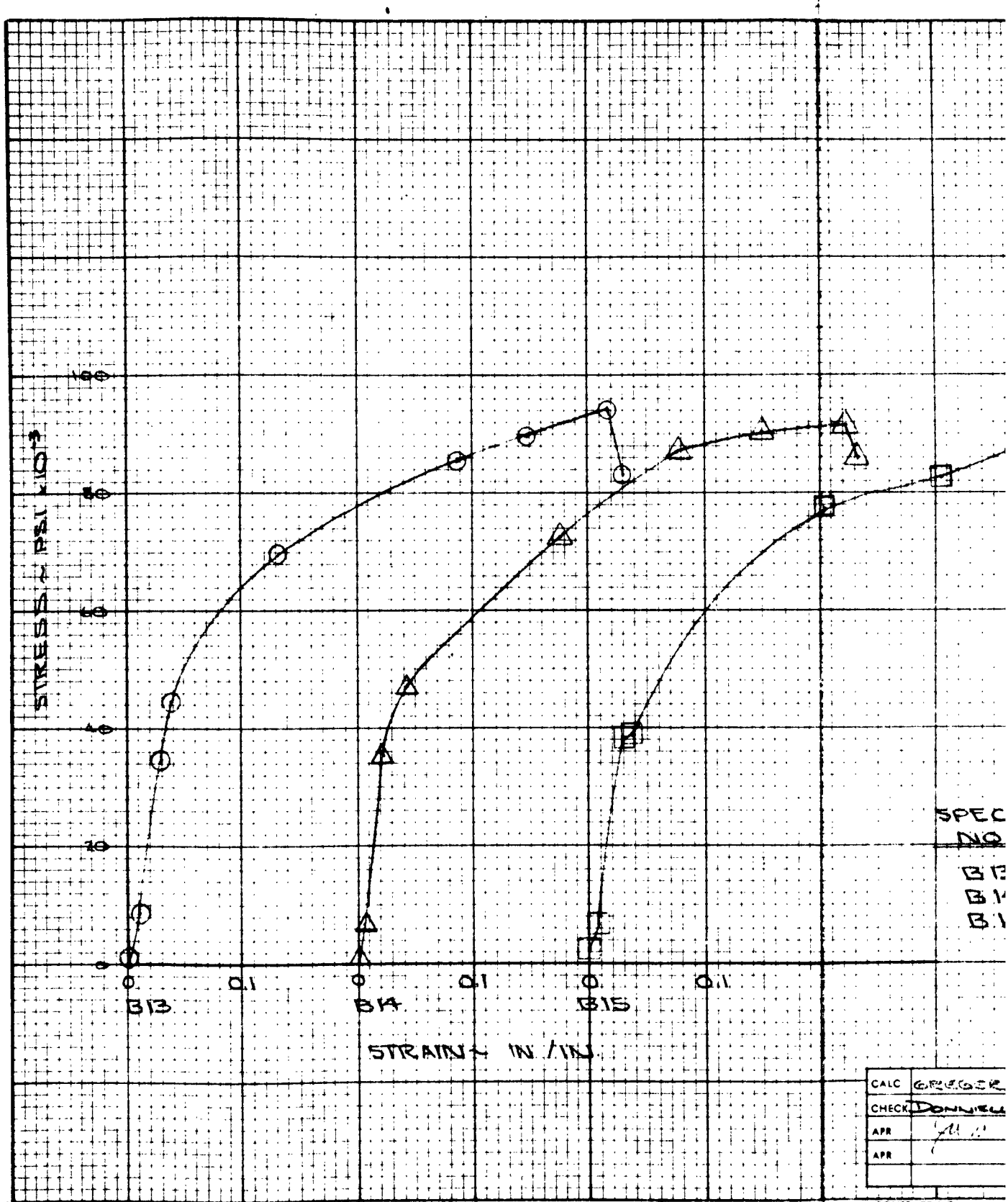
SPEC NO	AREA SQ. IN	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS
B-72	.0635	79,000	LONG	800	AIR
B-73	.0639	82,000	LONG	800	AIR
B-18X	.0628	76,000	LONG	800	AIR

(TYP.)

SEE PAGE 1-20 FOR NOTES

CALC	E. DENNEY	5/9/61	REVISED	DATE	STRESS STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CHECK	DONNELL	5-10-1				D2-800BU
APR.					BOEING AIRPLANE COMPANY	PAGE 1-76
APR.						

CONTRACT NO.

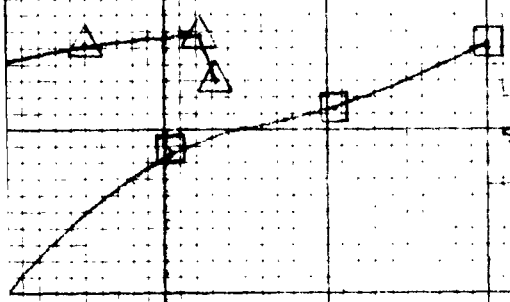


SPEC
NO
B1
B1
B1

CALC	
CHECK	DONNELL
APR	
APR	

DATA SHEET

CONTRACT NO.



SPEC NO.	ENERGY TO ULT. IN-LB/LB	ENERGY TO FAIL IN-LB/LB
B13	100,500	104,200
B14	101,000	104,900
B15	92,000	99,000

STRAIN ~ IN./IN.

← 0.1 →

STRAIN RATE ~ IN./IN./MIN.

290 IN./IN./MIN.

SPEC NO.	AREA ~SQ IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP (°F)	TEST ATMOS
B13	.0645	94,300	LONG.	72	AIR
B14	.0659	91,800	LONG.	72	AIR
B15	.0646	90,600	LONG.	72	AIR

2

			REVISED	DATE
CALC	G. FRISCH	1-27-1		
CHECK	DONNELL	1-30-1		
APR		1-30-1		
APR				

STRESS - STRAIN CURVES
INCONEL
.127 GAGE SHEET

BOEING AIRPLANE COMPANY

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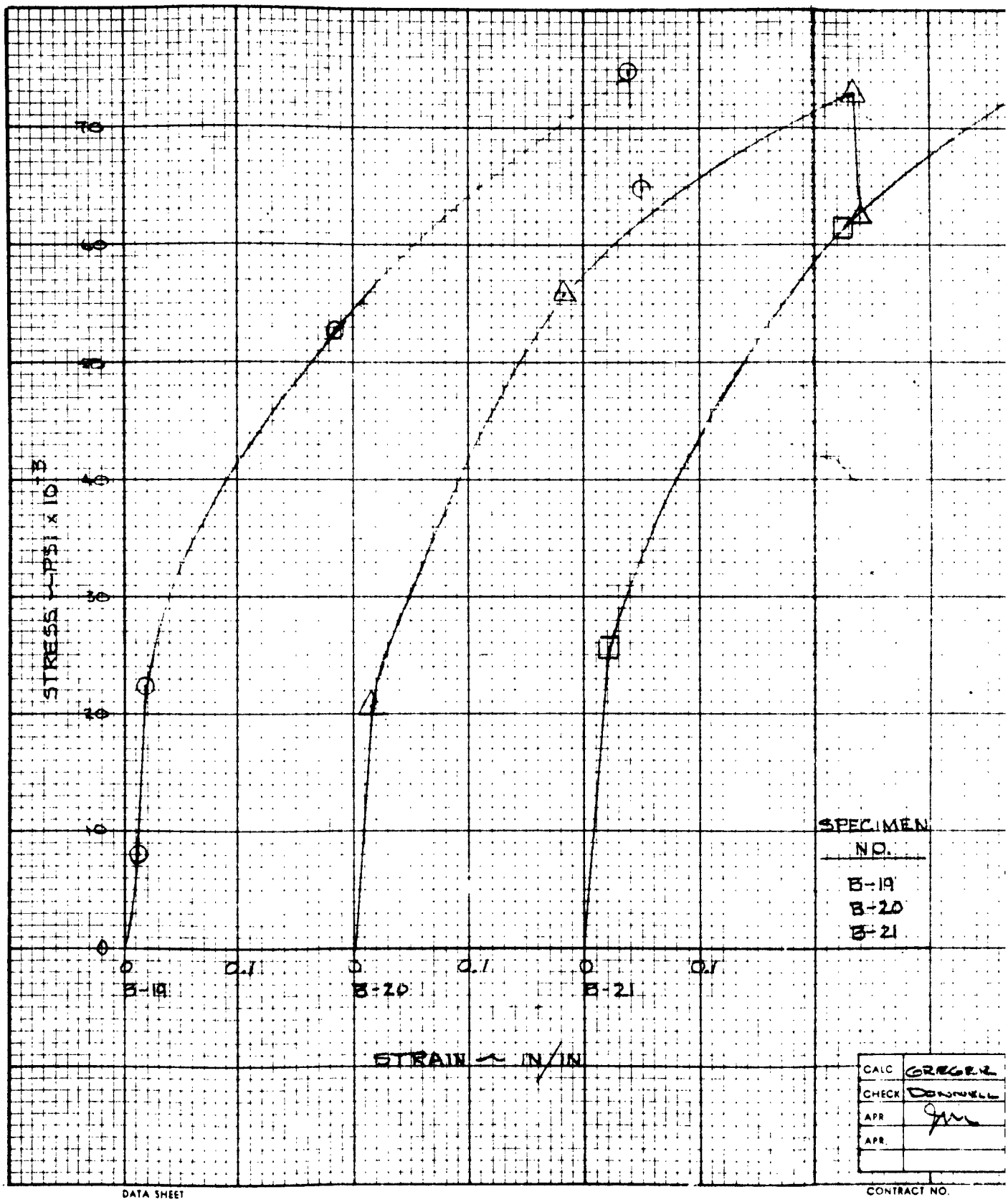
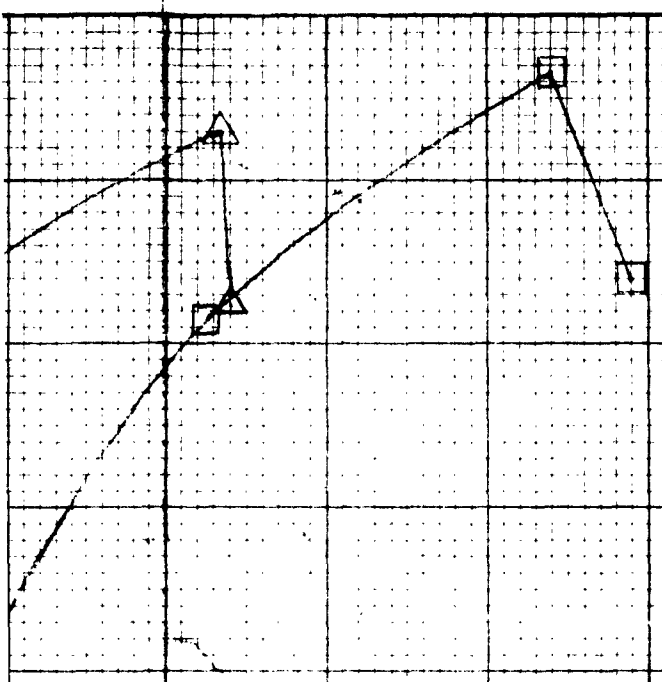
D2-80086
PAGE 127

CONTRACT NO.



DATA SHEET

CONTRACT NO.



SPEC. NO.	ENERGY TO ULT, IN-lb/lb	ENERGY TO FAIL, IN-lb/lb
B-19	76,500	80,870
B-20	78,700	79,500
B-21	82,470	94,570

STRAIN ± IN/IN
← .01 →

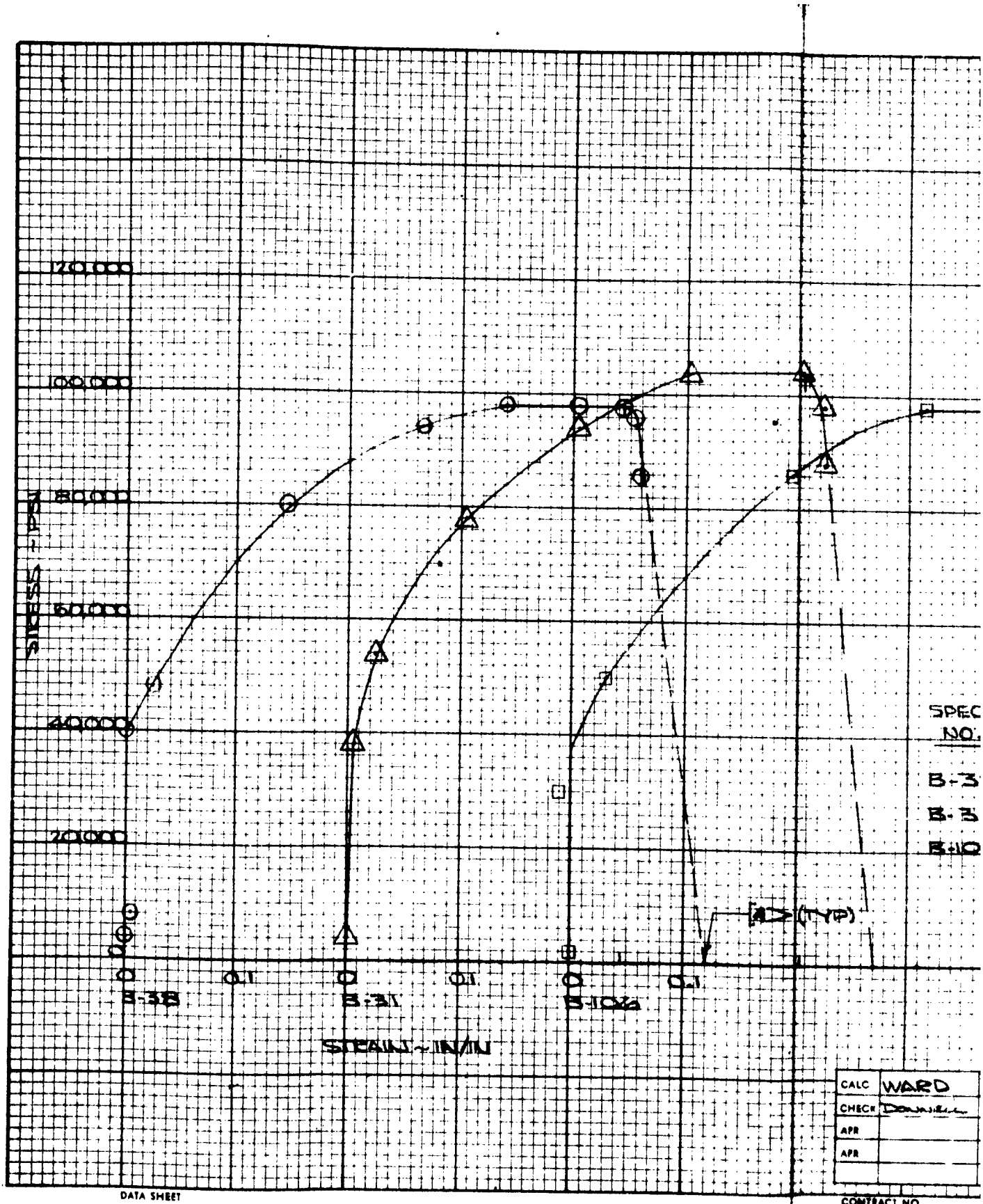
STRAIN RATE ± IN/IN/MIN.
.200 (TYP)

2

SPECIMEN NO.	AREA ±SQ. IN.	ETU ±PSI	GRAIN DIRECTION	TEST TEMP (°F)	TEST ATMOS.
B-19	.0647	74,300	LONG.	800	AIR
B-20	.0648	75,000	LONG.	800	AIR
B-21	.0647	76,500	LONG.	800	AIR

			REVISED	DATE	STRESS - STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CALC	GREGORE	1-27-1				D2-80086
CHECK	DONNELL	1-30-1				
APR		1-30-1			BOEING AIRPLANE COMPANY	PAGE 178
APR						

CONTRACT NO.



CALC	WARD
CHECK	
APR	
APR	

DATA SHEET

CONTRACT NO

2

SPEC. NO.	ENERGY TO ULT-IN-LB/LB	ENERGY TO FAILURE-IN-LB/LB
B-38	122,600	136,000
B-31	116,700	129,400
B-106	113,300	128,900

STRAIN IN/IN ← 0.1 →

STRAIN RATE IN/IN/MIN 300

SPEC. NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP-°F	TEST ATMOS.
B-38	.0637	98,000	LONG.	-65	NITROGEN
B-31	.0632	104,000	LONG.	-65	NITROGEN
B-106	.0632	98,000	LONG.	-65	NITROGEN

+SEE PAGE 120 FOR NOTES

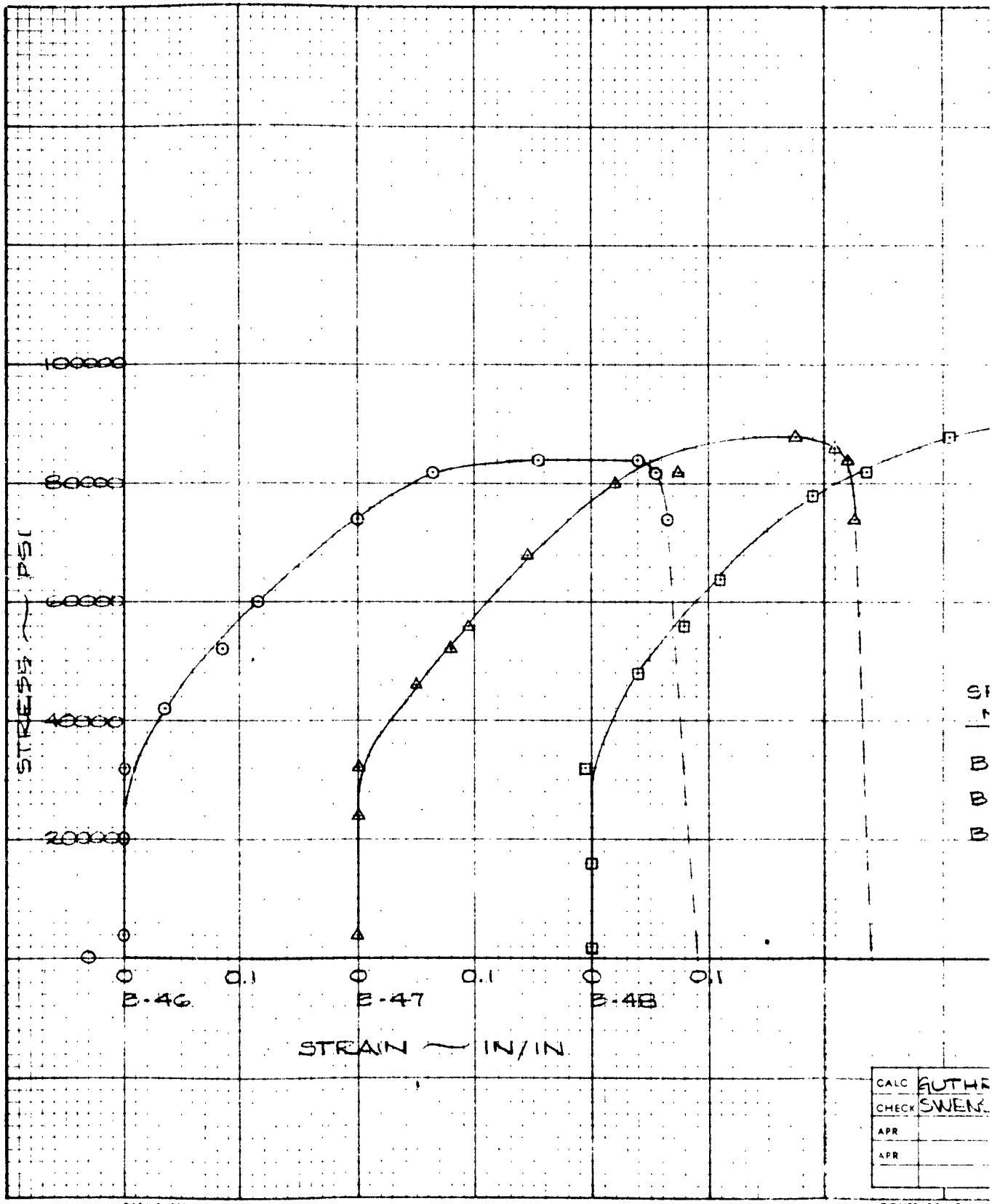
			REVISED	DATE
CALC	WARD	3-28-1		
CHECK	Donnell	4-12-61		
APP				
APP				

STRESS-STRAIN CURVES
INCONEL
.127 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A
D2-80086
PAGE 119

CONTRACT NO

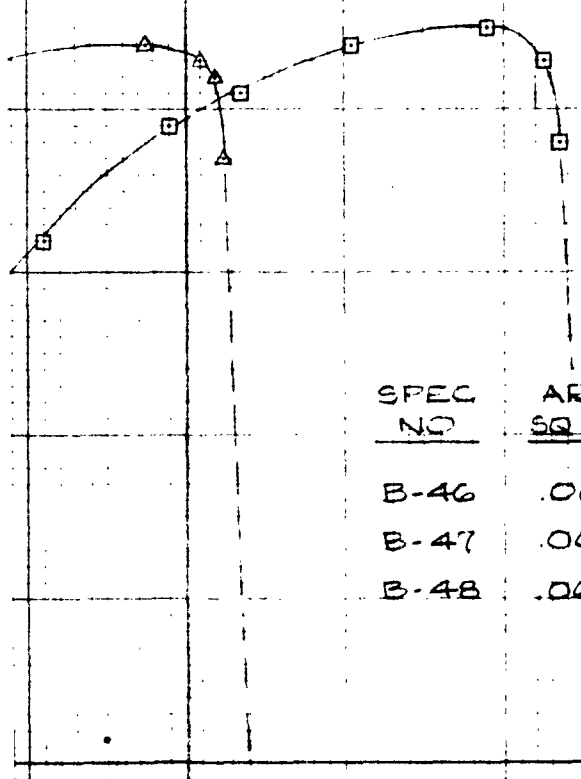


CALC GUTHR
CHECK SWEN
APR
APR

DATA SHEET

CONTRACT NO

U3 4011 5000—REV 7/60 (WAS BAC 1600)



SPEC. NO	ENERGY TO FTU - IN-LB/IN³	ENERGY TO FAILURE - IN-LB/IN³
B46	101,500	111,700
B47	96,600	102,700
B48	103,000	110,500

STRAIN IN/IN — 0.1

STRAIN RATE IN/IN/MIN — 300

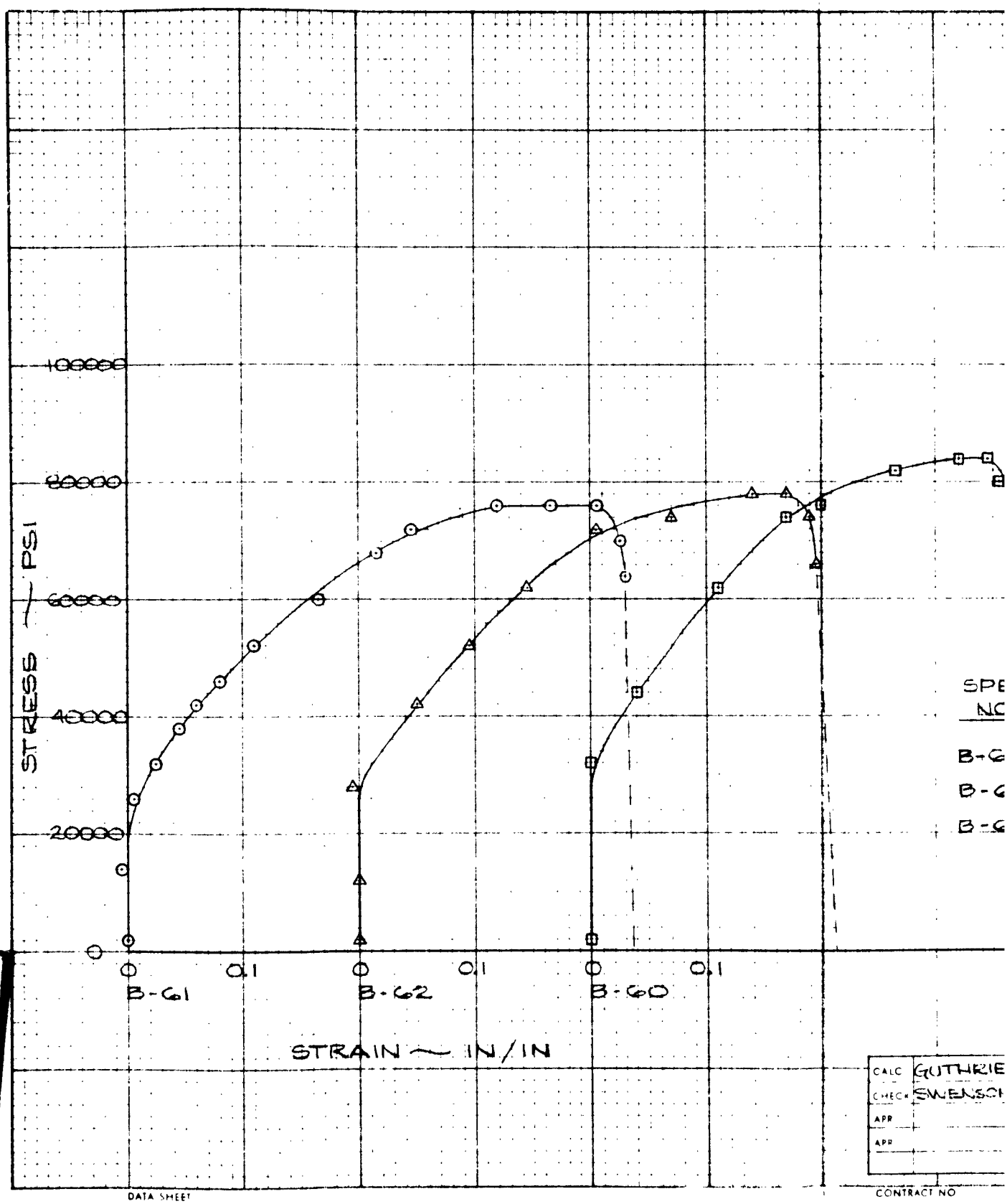
SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP - °F	TEST ATMOS
B-46	.0639	84000	LONG.	250	AIR
B-47	.0642	82000	LONG.	250	AIR
B-48	.0632	90000	LONG.	250	AIR

2

SEE PAGE 1-20 FOR NOTES

CALC GUTHRIE 4-13-1	REVISED	DATE	STRESS - STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CHECK SWENSON 4-13-1				D2-80086
APR			BOEING AIRPLANE COMPANY	PAGE 1-90
APR				

CONTRACT NO



SPE
NC

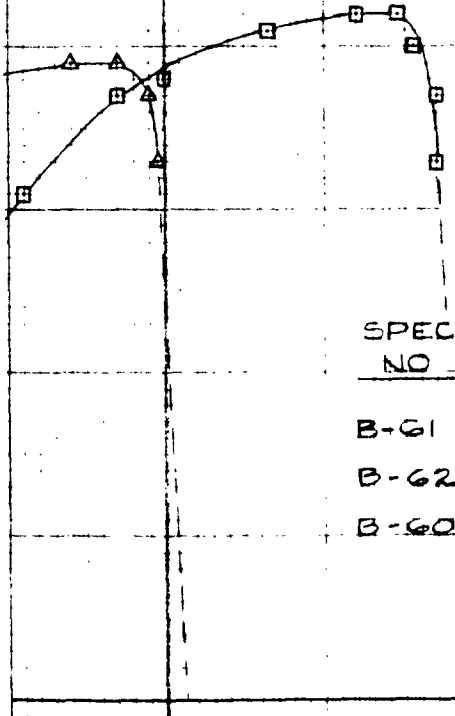
B-6
B-6
B-6

CALC	GUTHRIE
CHECK	SWENSO
APR	
APR	

DATA SHEET

CONTRACT NO

U3 4011 5000--REV 7/60 (WAS BAC 360[illegible]



SPEC NO.	ENERGY TO FTU IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
B61	83,200	88,900
B62	79,600	85,500
B60	79,200	86,500

STRAIN IN/IN	STRAIN RATE IN/IN/MIN
0.1	300

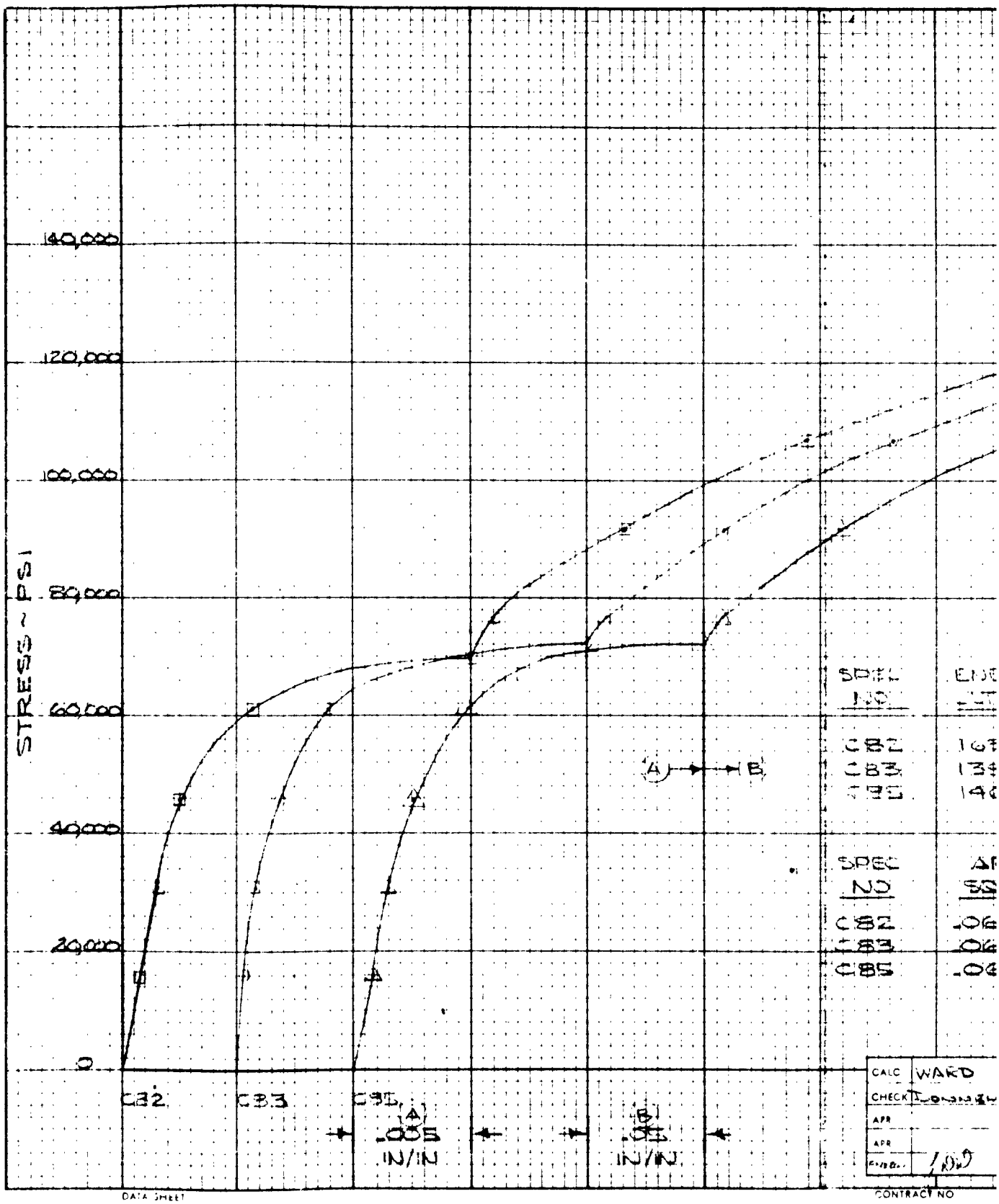
SPEC NO	AREA SQ IN	FTU PSI	GRAIN DIRECTION	TEST TEMP ~ °F	TEST ATMOS
B-61	.0638	76000	LONG.	600	AIR
B-62	.0631	78000	LONG.	600	AIR
B-60	.0635	84000	LONG.	600	AIR

2

SEE PAGE 1-20 FOR NOTES

CALC GUTHRIE 4-14-1	REVISED	DATE	STRESS-STRAIN CURVES INCONEL .127 GAGE SHEET	X-20A
CHECK SWENSON 4-18-1				D2-80086
APP			BOEING AIRPLANE COMPANY	PAGE 1-21
APP				

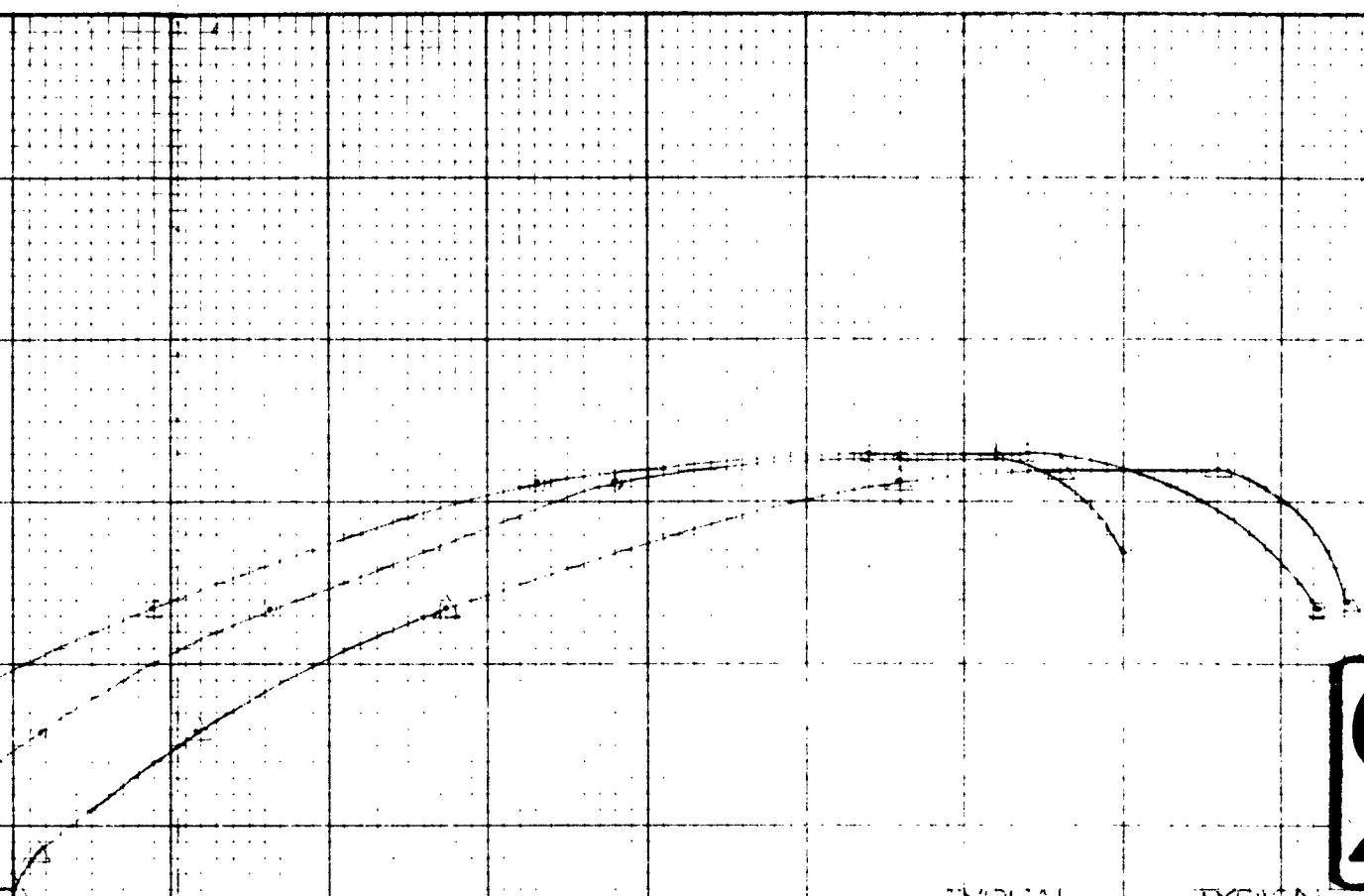
CONTRACT NO



DATA SHEET

CONTRACT NO

UT 4011 5000—REV 7/60 (WANG BAG PAID)



2

SPEC NO.	ENERGY TO RUPTURE IN-LB/LB	ENERGY TO FAILURE IN-LB/LB	TYPICAL STRAIN IN/IN	TYPICAL STRAIN RATE IN/IN/MIN
C82	167,000	202,000	(A) = .005	(A) = .005
C83	138,800	156,200	(B) = .05	B = .10
C85	146,500	163,000		

SPEC NO	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOSPHERE
C82	.0634	123,100	LONG.	-65	NITROGEN
C83	.0656	125,800	LONG.	-65	NITROGEN
C85	.0653	124,000	LONG.	-65	NITROGEN

CALC	WARD	2-24-61	REVISED	DATE	STRESS-STRAIN CURVES HASTELLOY "X" .125 GAGE SHEET
CHECK		3-6-61			
APP					
APP					

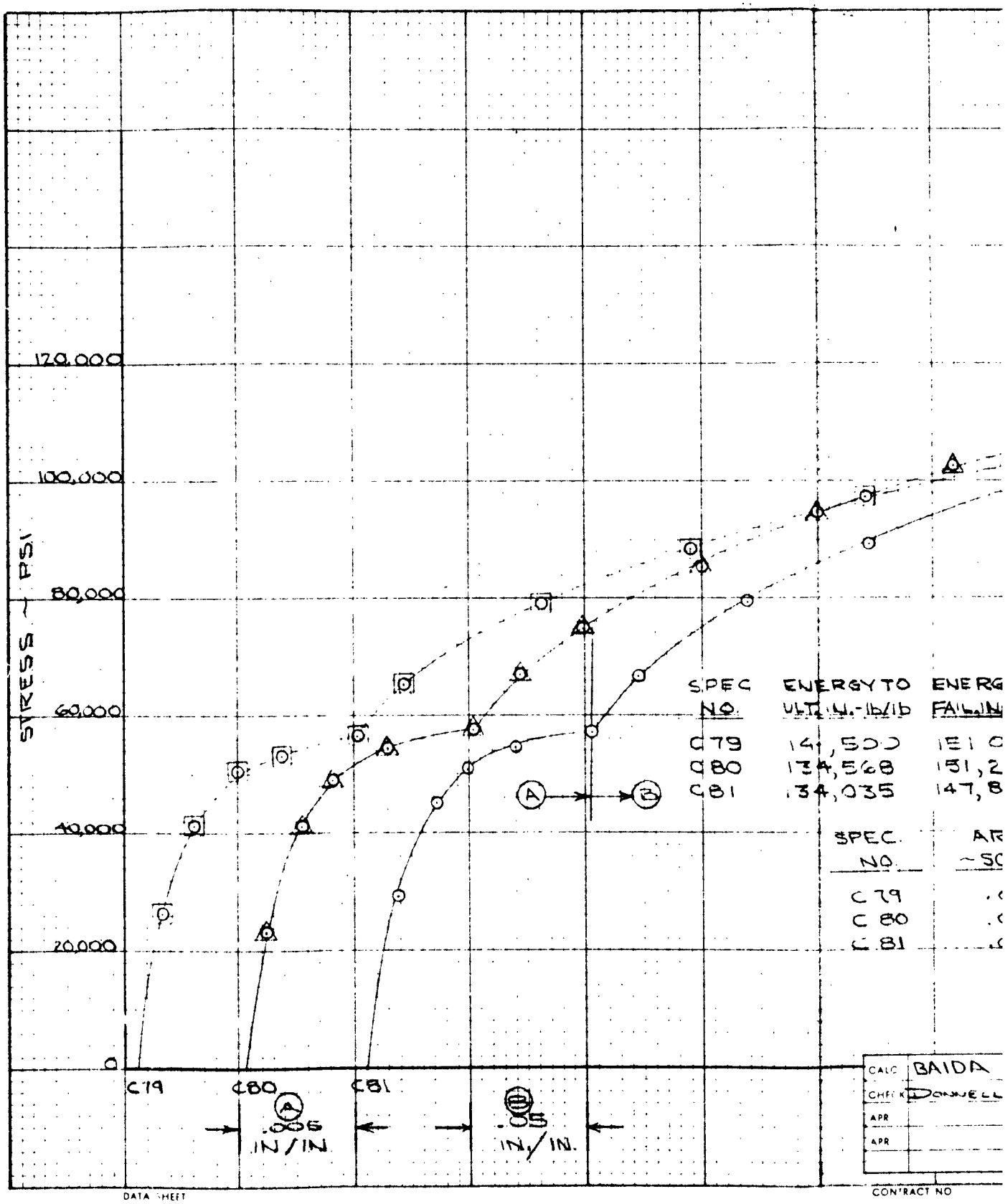
X-20A

D2-80084

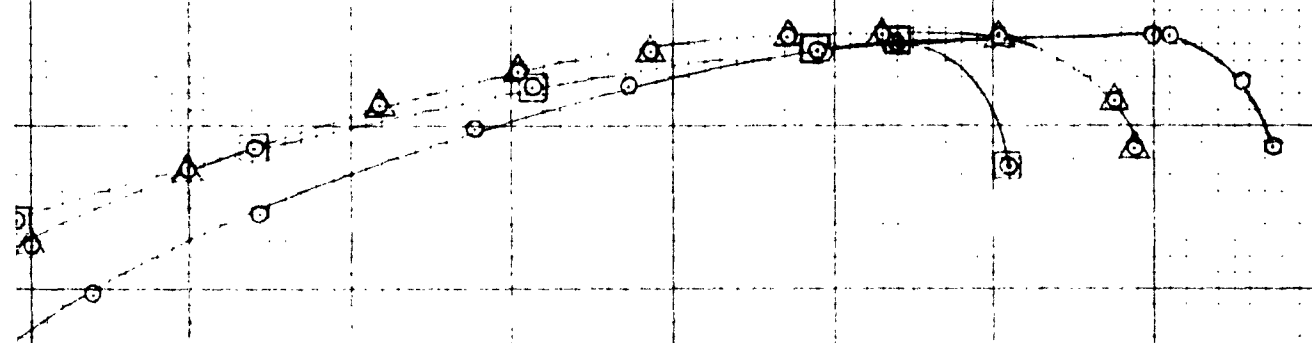
BOEING AIRPLANE COMPANY

PAGE 1-A-2

CONTRACT NO



U3 4011 5000—REV 7/60 (WAS BAC 360)



2

SPEC NO	ENERGY TO ULT. IN-lb/lb	ENERGY TO FAIL IN-lb/lb	TYP. STRAIN ~ IN./IN.	TYP. STRAIN RATE ~ IN./IN./MIN.
C 79	141,500	151,000	(A) = 005	(A) = 005
C 80	134,568	151,268	(B) = .05	(B) = .10
C 81	134,035	147,865		

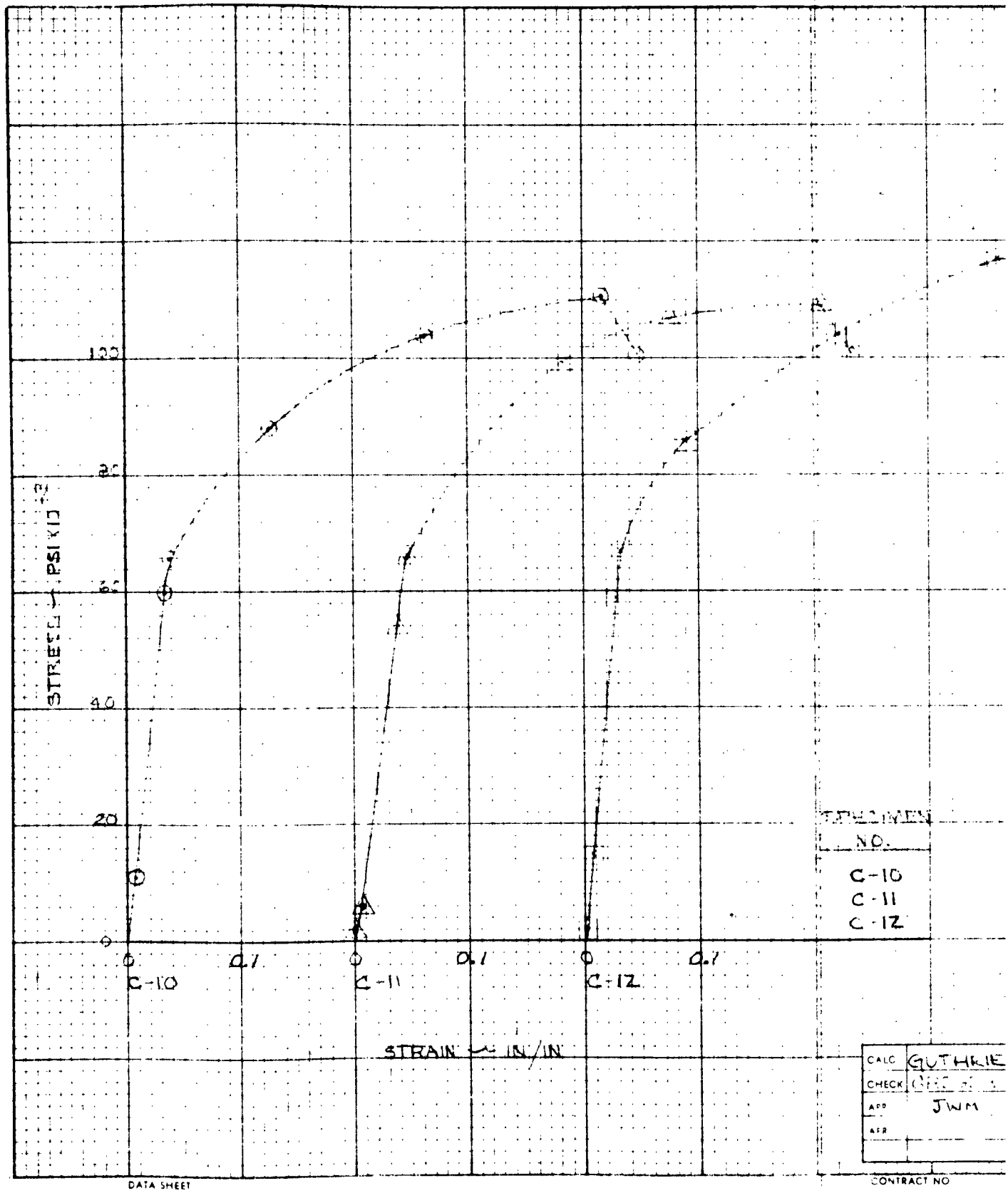
SPEC NO	AREA ~ SQ. IN.	FTU ~ PSI	GRAIN DIRECT	TEST TEMP. (°F)	TEST ATMOS.
C 79	.0661	110,700	LONG	72	AIR
C 80	.0660	111,200	LONG	72	AIR
C 81	.0655	111,100	LONG	72	AIR

CALC	BAIDA	1-4-61	REVISED	DATE
CHECK	DONNELL	1-14-61		
APR				
APR				

STRESS — STRAIN CURVES X-20A
HASTELLOY X
.125 GAGE SHEET D2-800BG

BOEING AIRPLANE COMPANY

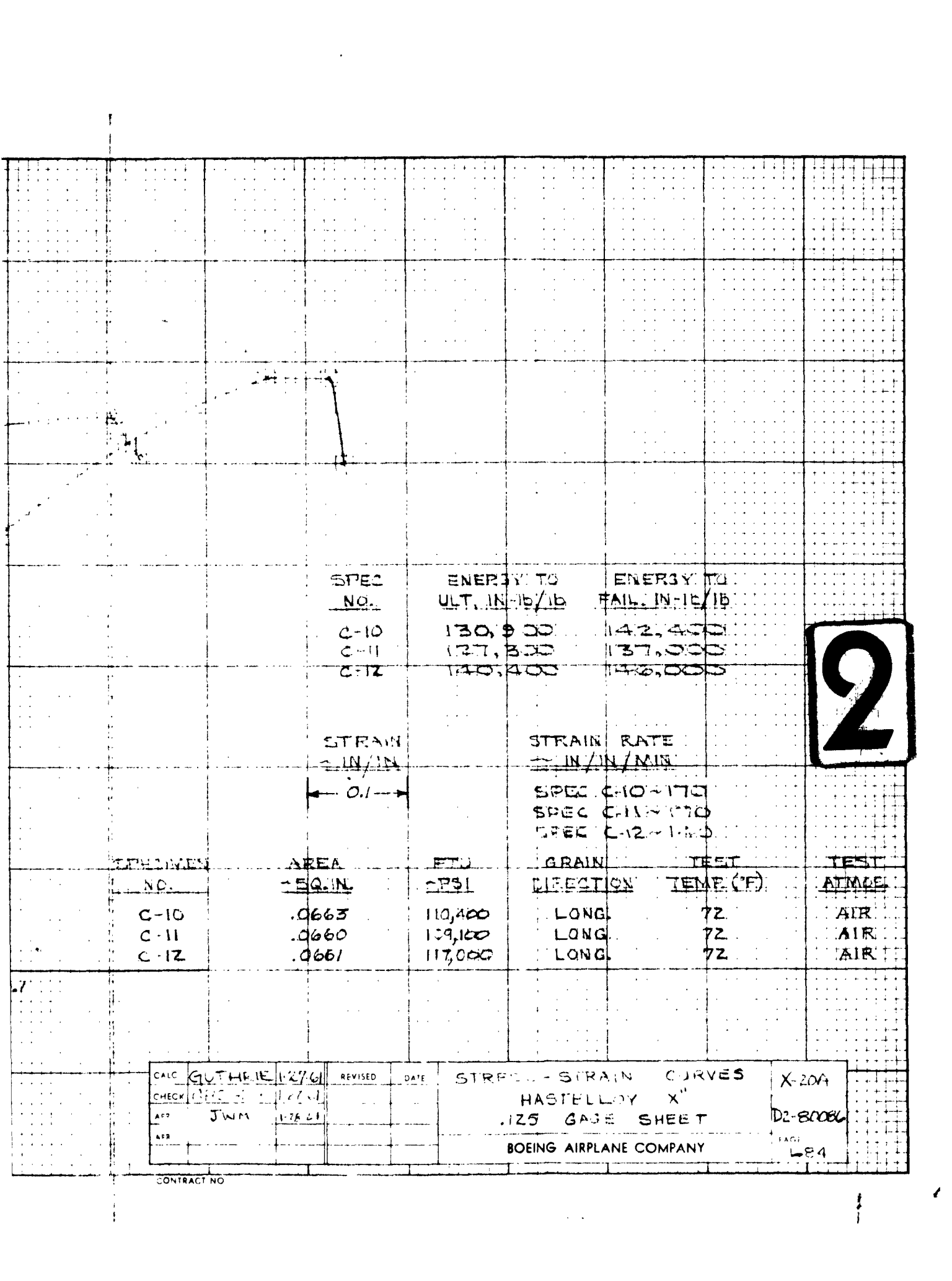
CONTRACT NO



DATA SHEET

CONTRACT NO

U3 4011 5000—REV 7/60 (WAS BAC 3600)



SPEC NO.	ENERGY TO ULT. IN-lb/lb	ENERGY TO FAIL. IN-lb/lb
C-10	130,900	142,400
C-11	127,300	137,000
C-12	140,400	146,000

2

STRAIN ≈ IN/IN

0.1

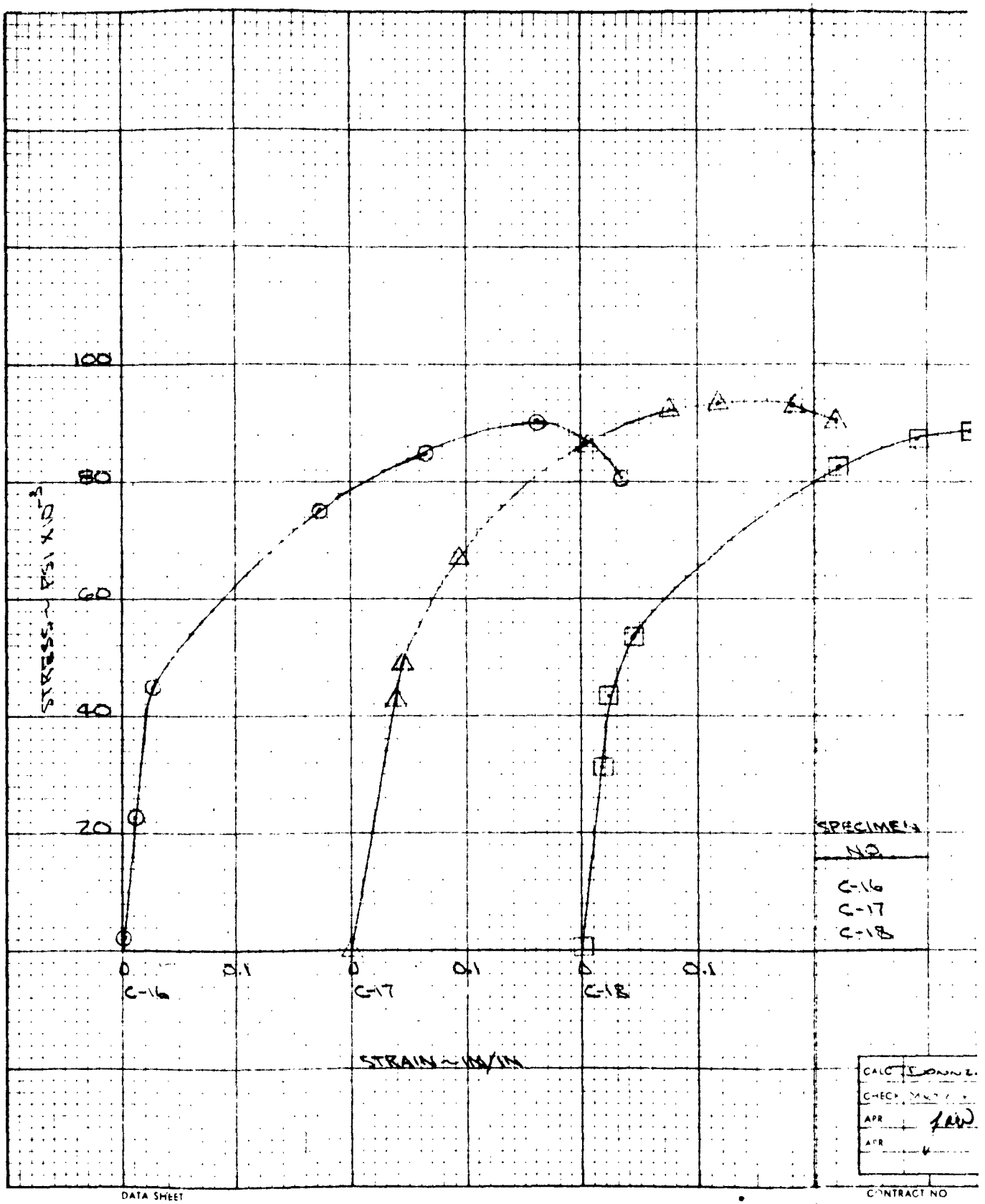
STRAIN RATE ≈ IN/IN/MIN

SPEC C-10 ~ 170
SPEC C-11 ~ 170
SPEC C-12 ~ 1.5

SPECIMEN NO.	AREA ~SQ.IN.	ETU ~PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
C-10	.0663	110,400	LONG.	72	AIR
C-11	.0660	109,100	LONG.	72	AIR
C-12	.0661	117,000	LONG.	72	AIR

CALC	GUTHRIE 12/6	REVISED	DATE	STRESS - STRAIN CURVES	X-20A
CHECK	[illegible] 12/6			HASTELLOY "X"	D2-80086
APP	JWM 12/6/61			.125 GAGE SHEET	
APP				BOEING AIRPLANE COMPANY	PAGE L-84

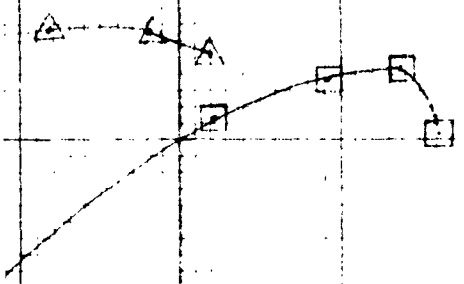
CONTRACT NO



1

DATA SHEET

CONTRACT NO



SPEC. NO.	ENERGY TO UT. IN-LB/IN³	ENERGY TO FAIL. IN-LB/IN³
C-16	88,000	108,700
C-17	99,000	111,800
C-18	81,500	88,500

2

STRAIN -IN/IN

← 0.1 →

STRAIN RATE -IN/IN/MIN

185 TYP.

SPECIMEN NO.	AREA ~SQ IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
C-16	.0451	90,450	LONG.	600°	AIR
C-17	.0454	93,370	LONG	600°	AIR
C-18	.0452	89,500	LONG	600°	AIR

3.1

CALC			REVISED	DATE
CHECK				
APP				
APP				

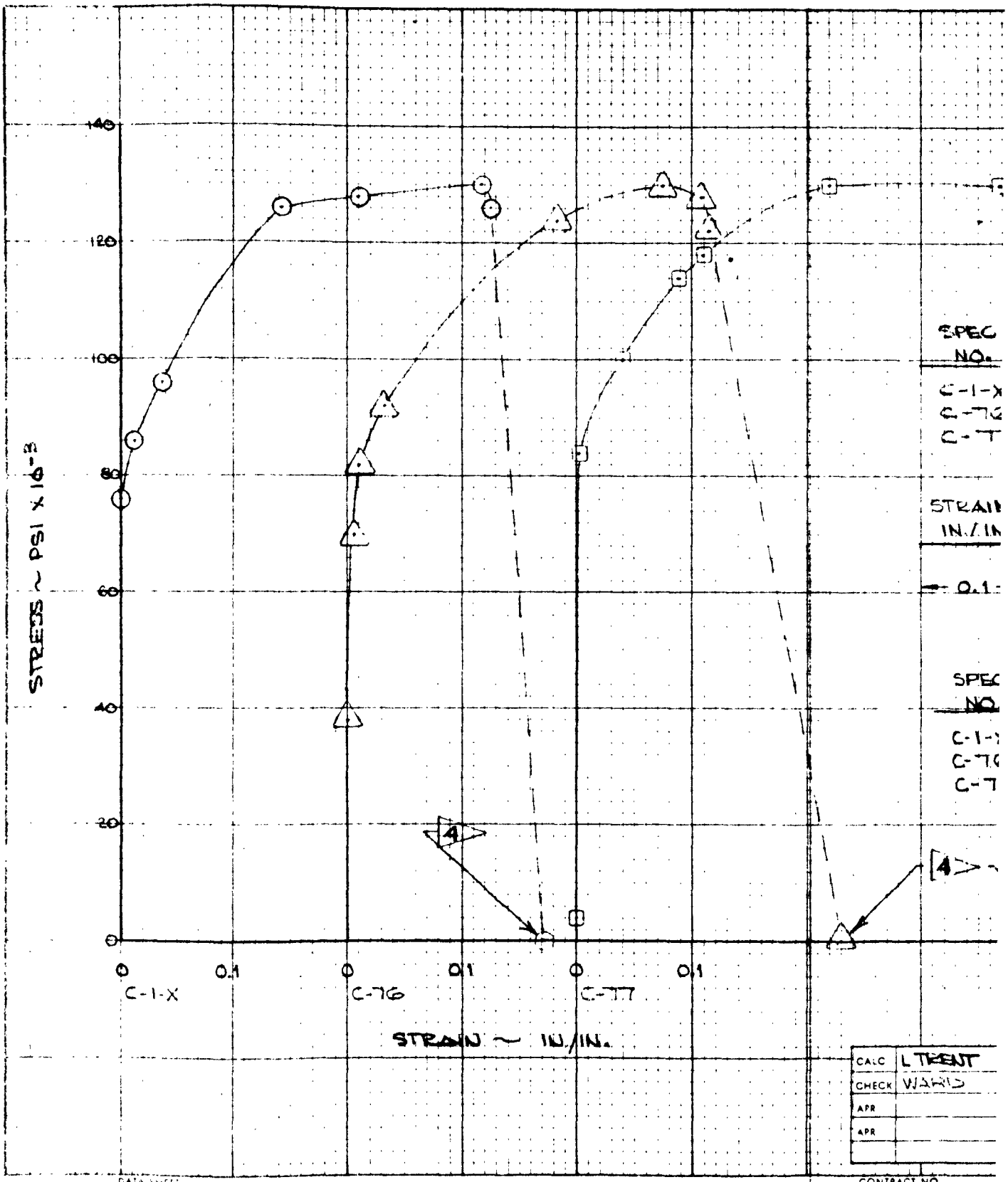
STRESS-STRAIN CURVES
HASTELLOY "X"
.125 GAGE SHEET

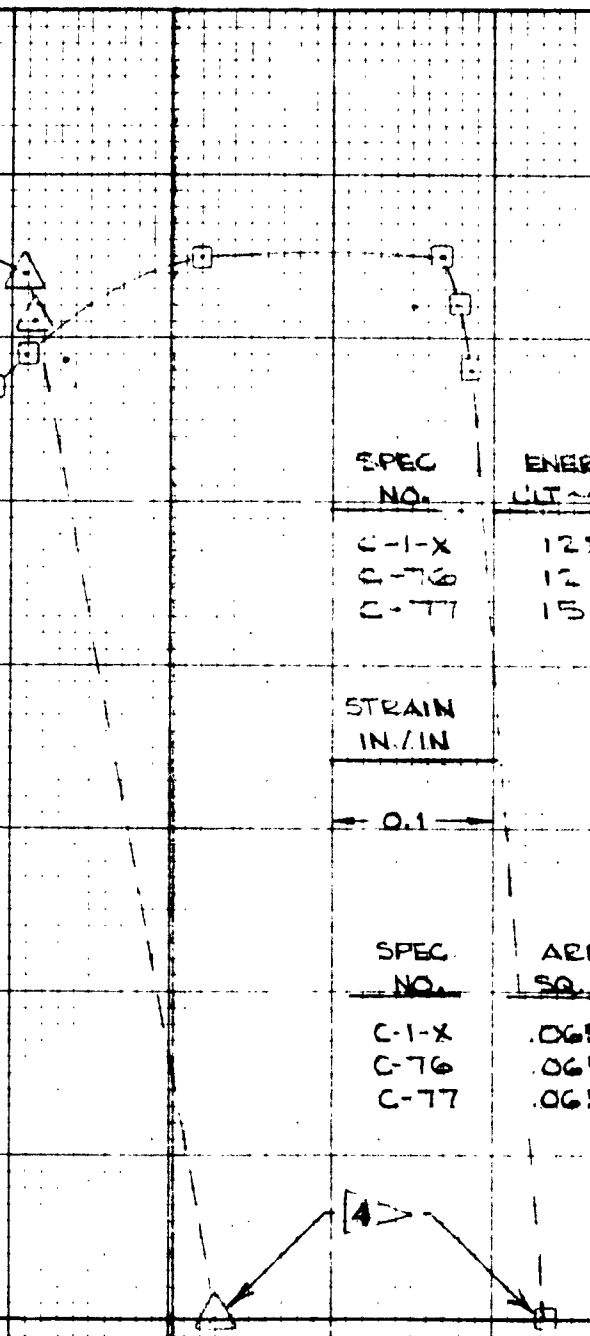
X-20A
D2-8008

BOEING AIRPLANE COMPANY

PAGE 1-25

CONTRACT NO


STRESS ~ PSI x 10⁻³
140
120
100
80
60
40
20
0
0
0.1
C-1-X
C-76
C-77
STRAIN ~ IN./IN.
SPEC NO.
C-1-X
C-76
C-77
STRAIN IN./IN.
0.1
SPEC NO.
4
CALC
CHECK
APR
APR
DATA SHEET
CONTRACT NO.



SPEC NO.	ENERGY TO ULT ~ IN-LB/LB.	ENERGY TO FAIL ~ IN-LB/LB.
C-1-X	128,900	142,900
C-76	121,030	148,480
C-77	152,390	169,240

STRAIN IN./IN	STRAIN RATE IN/IN/MIN.
0.1	200

SPEC NO.	AREA, SQ. IN.	FTU, ~PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
C-1-X	.0654	130,000	LONG.	-65	NITROGEN
C-76	.0659	130,000	LONG.	-65	NITROGEN
C-77	.0651	130,000	LONG.	-65	NITROGEN

2

~ SEE PAGE 1-70 FOR NOTES ~

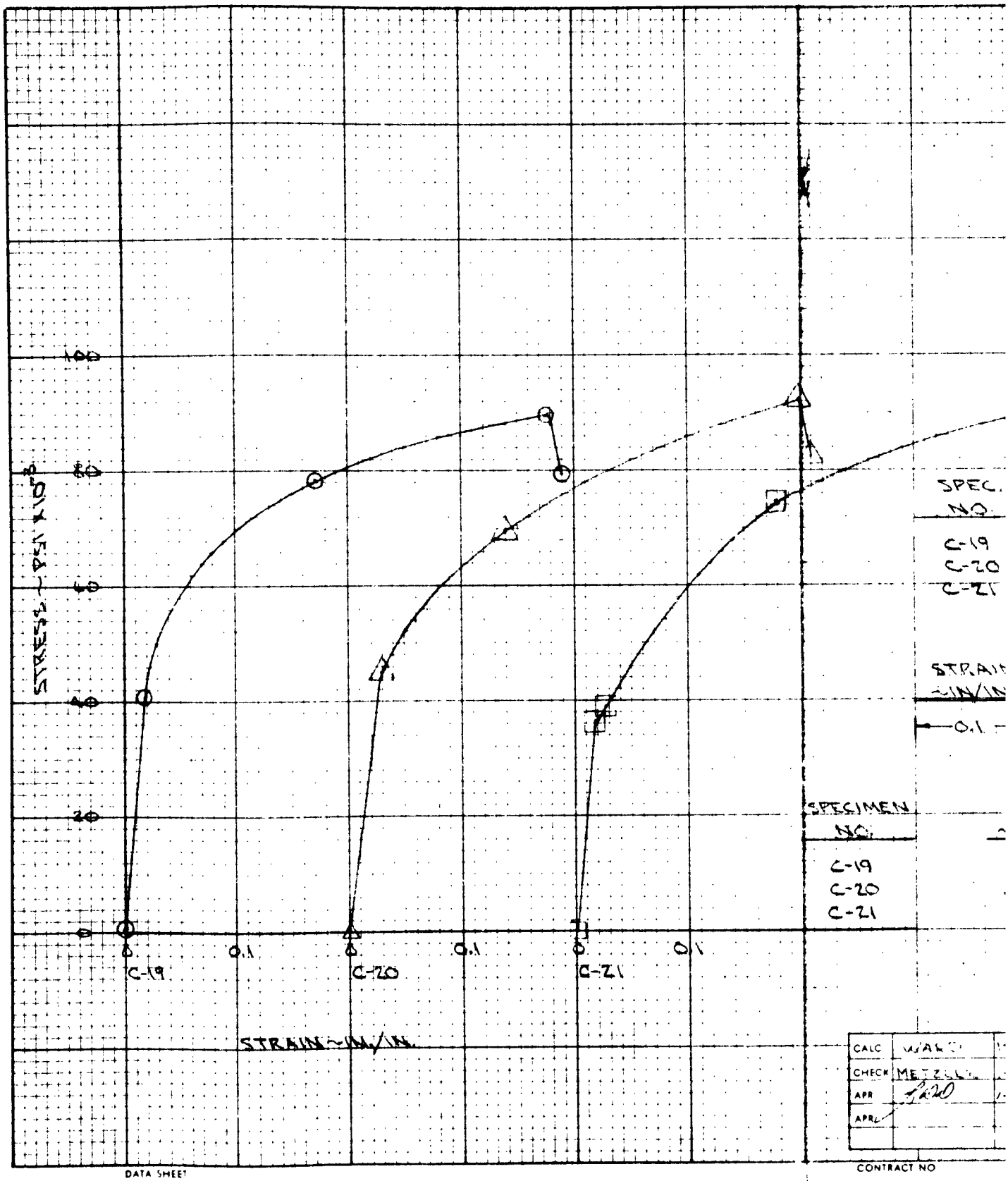
CALC	L TRENT	3-22-1	REVISED	DATE
CHECK	WARD	3-23-1		
APR				
APR				

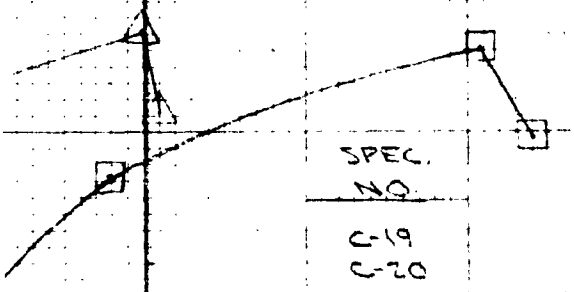
STRESS-STRAIN CURVES
HASTELLOY X
.125 GAGE SHEET

X-20A
D2 80086
LP6

BOEING AIRPLANE COMPANY

CONTRACT NO.


STRESS - PSI X 10³
100
80
60
40
20
0
0
0.1
0
0.1
0
0.1
C-19
C-20
C-21
STRAIN - IN./IN.
SPEC. NO.
C-19
C-20
C-21
STRAIN - IN./IN.
0.1
SPECIMEN NO.
C-19
C-20
C-21
CALC
CHECK
APR
APR
CONTRACT NO
DATA SHEET



SPEC. NO.	ENERGY TO WT. IN-LB/LB	ENERGY TO FAIL. IN-LB/LB
C-19	97,000	100,200
C-20	97,800	101,200
C-21	98,300	105,200

2

STRAIN ~IN/IN

0.1

STRAIN RATE ~IN/IN/MIN.

285 (TYP)

SPECIMEN NO.	AREA ~SQ IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
C-19	.0656	90,000	LONG.	800°	AIR
C-20	.0656	92,300	LONG.	800°	AIR
C-21	.0654	90,250	LONG.	800°	AIR

			REVISED	DATE
CALC	WAK	1-27		
CHECK	ME	1-30		
APP	[illegible]	1-30		
APPR				

STRESS-STRAIN CURVES
HASTELLOY "X"
.125 GAGE SHEET

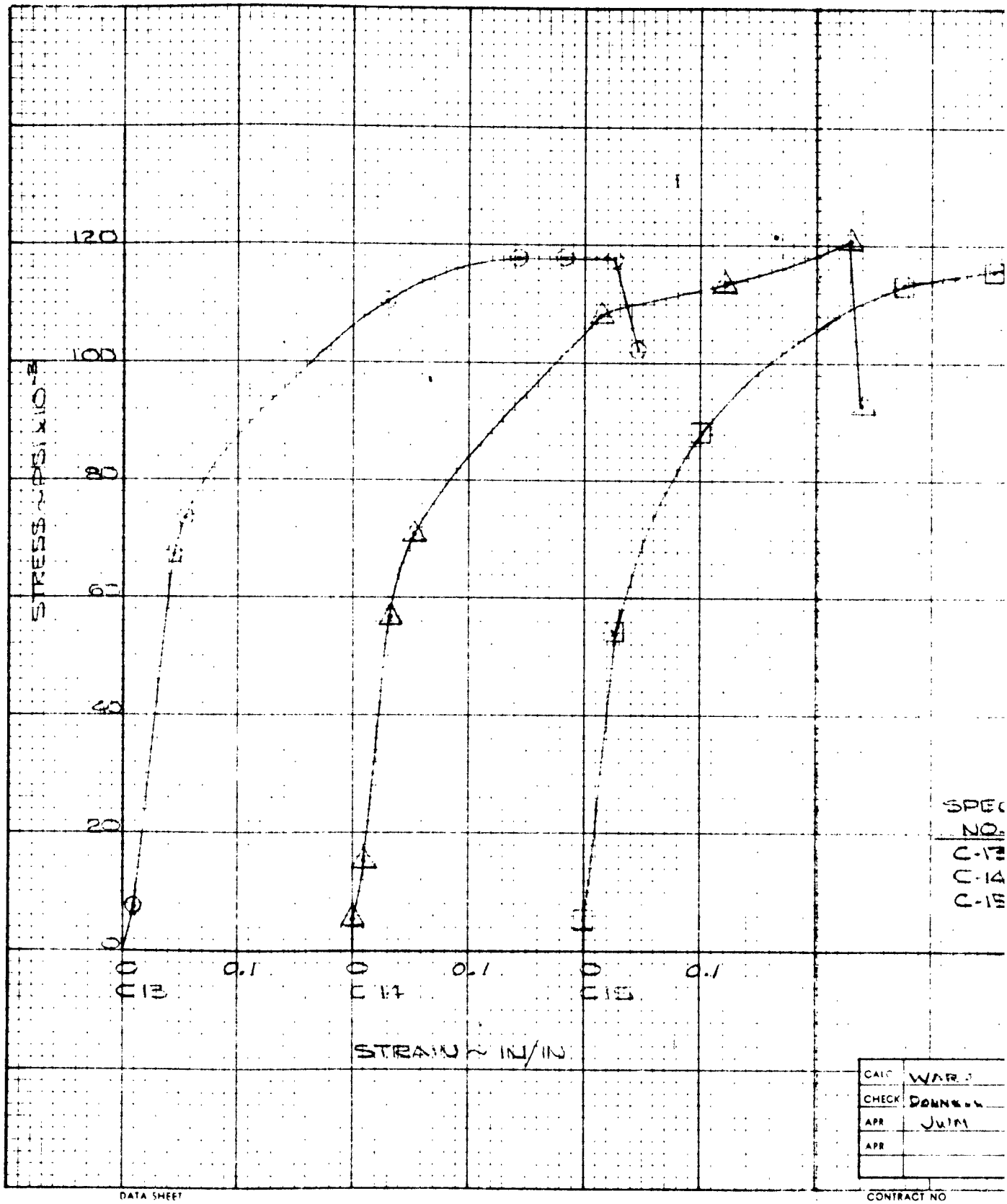
BOEING AIRPLANE COMPANY

X-20A

D2-60086

AS 168 1

CONTRACT NO



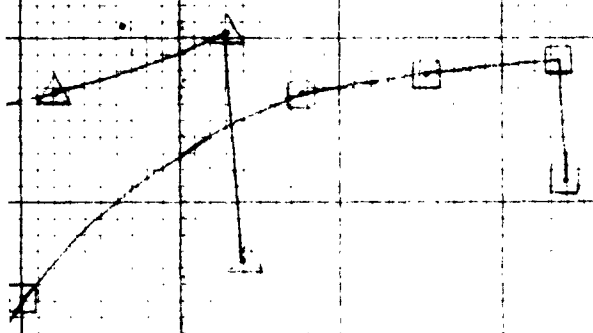
SPEC
NO.
C-13
C-14
C-15

CALC	WARD
CHECK	DOUNCE
APR	JUHN
APR	

DATA SHEET

CONTRACT NO

U3 4011 5000—REV 7/60 (WAS BAC 3600)



SPEC. NO.	ENERGY TO ULT. IN-LB/LB	ENERGY TO FAILURE IN-LB/LB
C-13	143,800	150,300
C-14	142,500	146,200
C-15	146,600	148,500

STRAIN ~IN/IN: 0.1

STRAIN RATE ~IN/IN/MIN: 295

SPEC NO.	AREA ~SQ.IN.	PTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS
C-13	.0659	117,970	LONG.	72	AIR
C-14	.0655	120,610	LONG.	72	AIR
C-15	.0656	117,350	LONG.	72	AIR

2

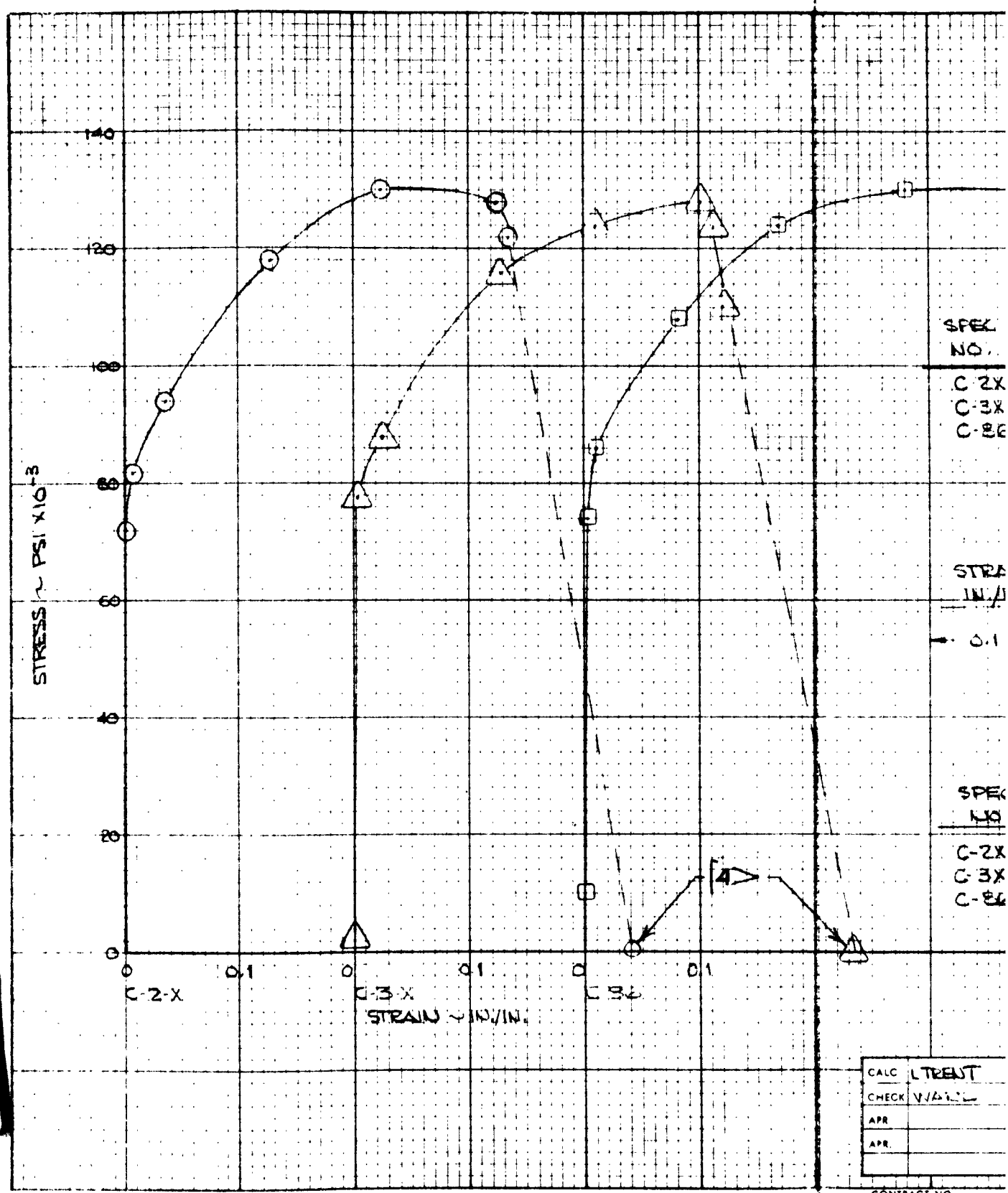
			REVISED	DATE
CALC	WATR	1-27-61		
CHECK	DOUNCE	1-28-61		
APR	JUAN	1-28-61		
APR				

STRESS-STRAIN CURVES
HASTELLOY "X"
.125 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A
D2-80086
PAGE 1-88

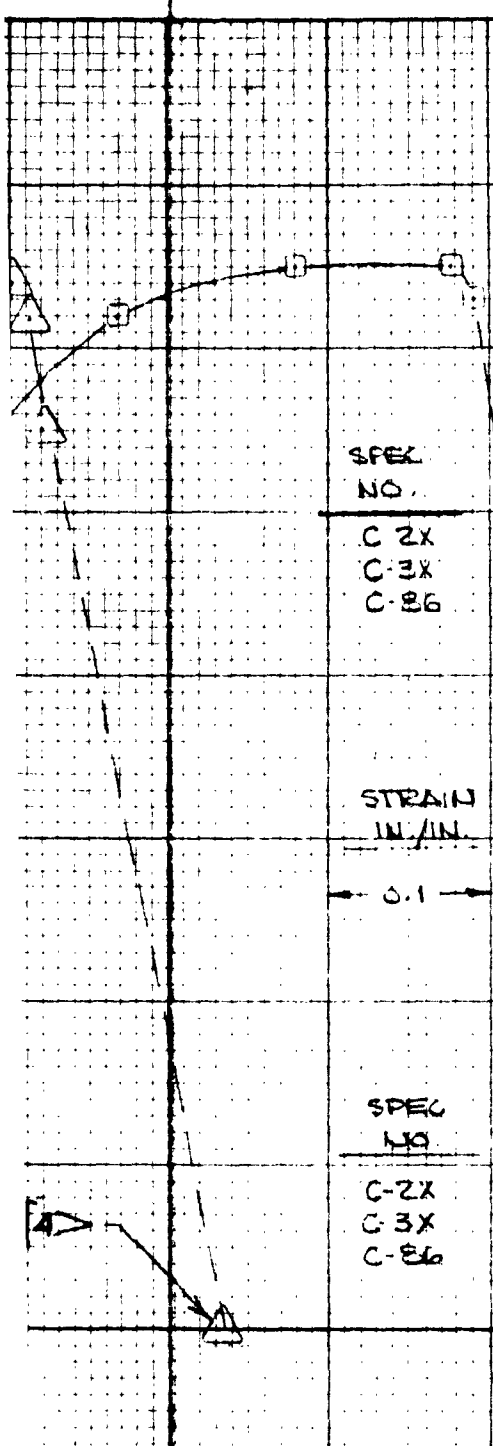
CONTRACT NO



CALC	L TREJST
CHECK	
APR	
APR.	

DATA SHEET

CONTRACT NO



SPEC. NO.	ENERGY TO ULT ~ IN-LB/LB.	ENERGY TO FAIL ~ IN-LB/LB.
C-2X	130,690	138,000
C-3X	117,240	147,790
C-86	153,320	180,760

STRAIN IN./IN.

0.1

STRAIN RATE IN./IN./MIN.

300

2

SPEC NO.	AREA SQ. IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP (°F)	TEST ATMOS.
C-2X	.0651	128,000	LONG.	-65	NITROGEN
C-3X	.0648	128,000	LONG.	-65	NITROGEN
C-86	.0656	130,000	LONG.	-65	NITROGEN

~SEE PAGE 20 FOR NOTES~

CALC	L TRENT	3-22-1	REVISED	DATE
CHECK	V/A[illegible]	3-23		
APR				
APR				

CONTRACT NO.

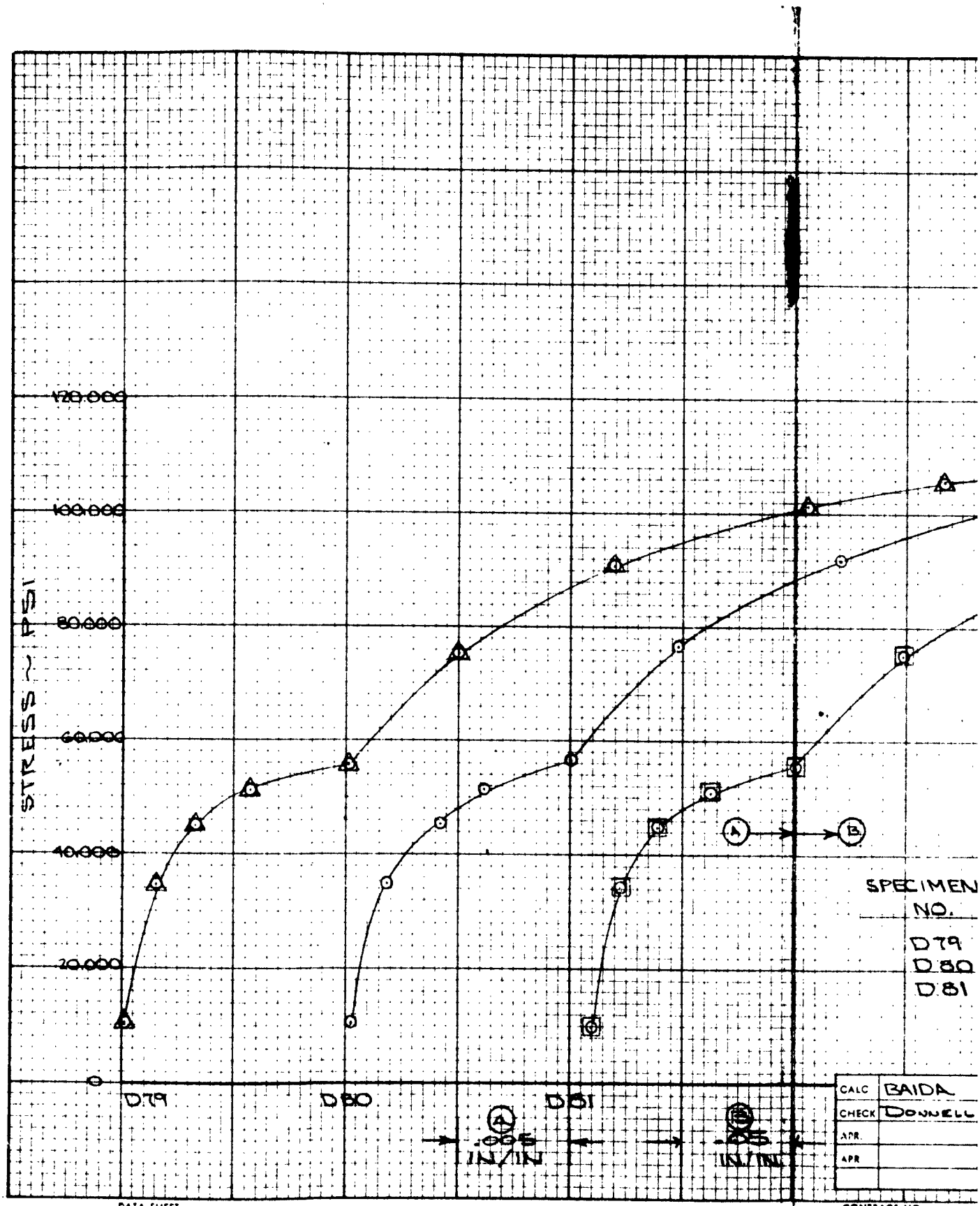
STRESS-STRAIN CURVES
HASTELLOY
.125 GAGE SHEET

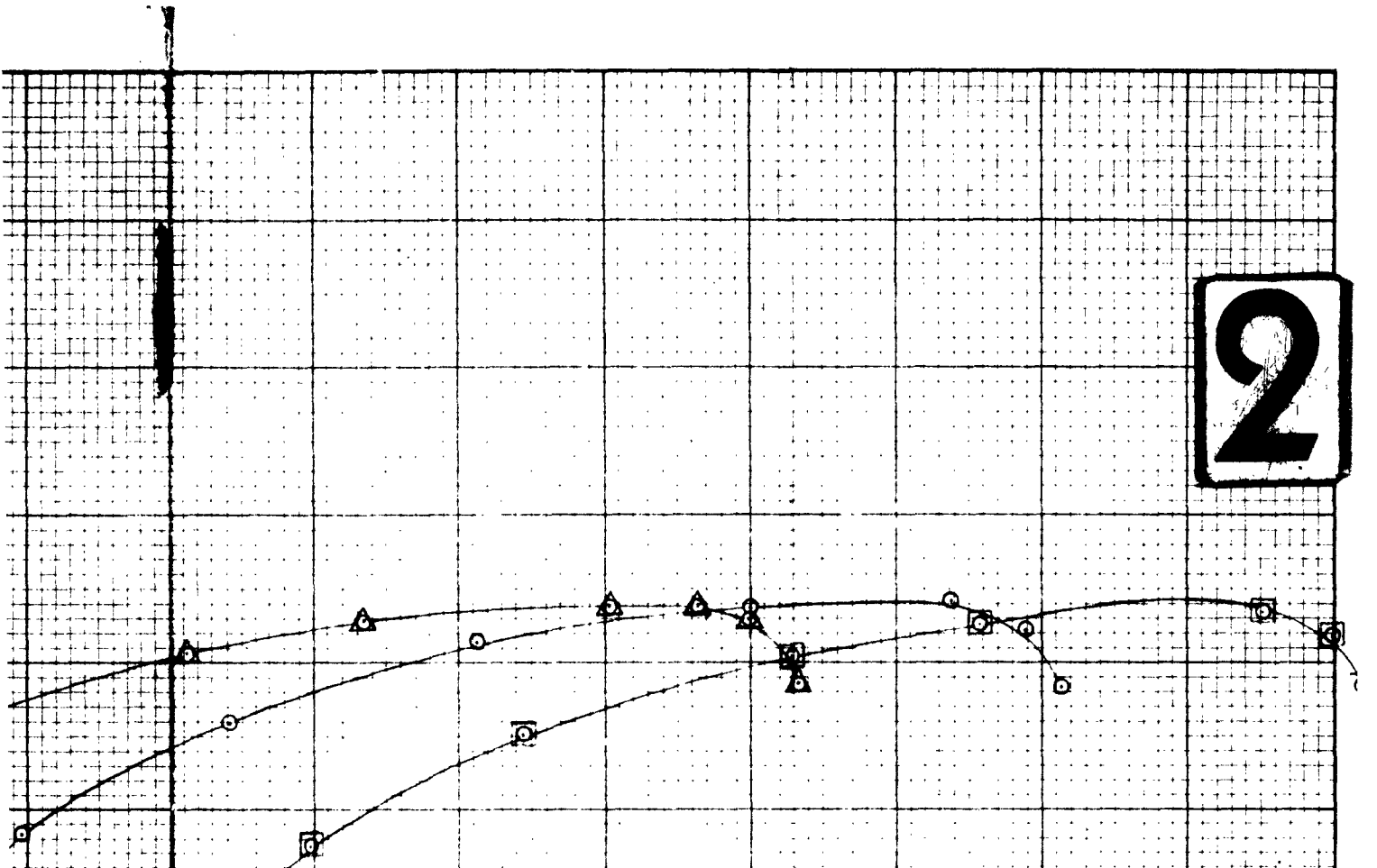
BOEING AIRPLANE COMPANY

X-20A

D2-80086

PAGE 1 of 1


STRESS - PSI
120,000
100,000
80,000
60,000
40,000
20,000
0
D79
D80
D81
A
B
.005
IN./IN.
.005
IN./IN.
SPECIMEN NO.
D79
D80
D81
CALC BAIDA
CHECK DONNELL
APR.
APR
DATA SHEET
CONTRACT NO.



	TYP. STRAIN ~IN./IN.	TYP. STRAIN RATE ~IN./IN./MIN.	SPEC NO.	ENERGY TO ULT. IN-lb/in³	ENERGY TO FAIL. IN-lb/in³
	(A) = .005	(A) = .005	D79	128,071	141,421
			D80	123,538	137,128
(A) → (B)	(B) = .05	(B) = .10	D81	123,826	136,336

SPECIMEN NO.	AREA ~SQ. IN.	FTU ~PSI	GRAIN DIRECT	TEST TEMP (°F)	TEST ATMOS.
D79	.0658	107,900	LONG.	72	AIR
D80	.0648	108,300	LONG.	72	AIR
D81	.0661	106,800	LONG.	72	AIR

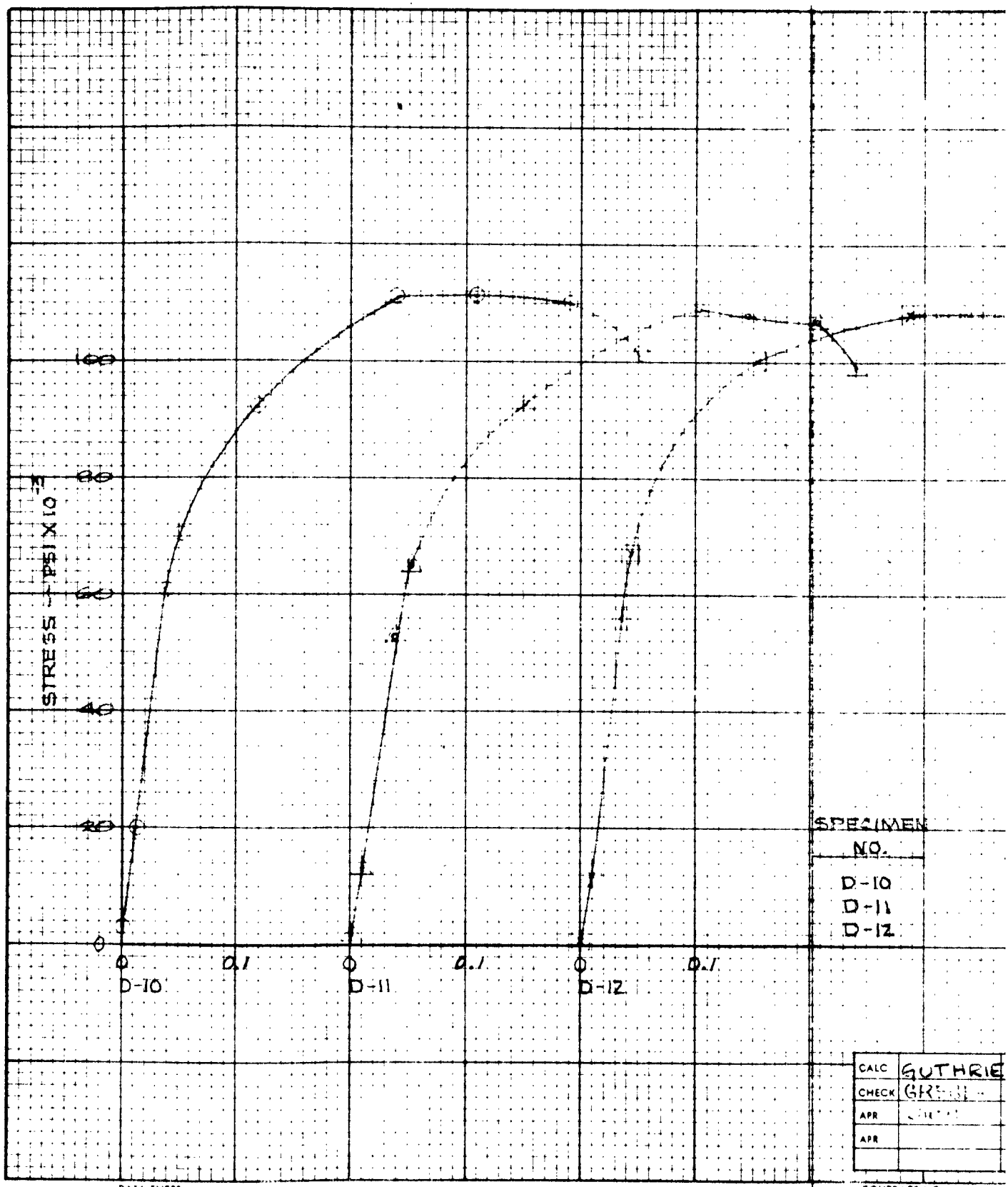
			REVISED	DATE
CALC	BAIDA	1-562		
CHECK	DONNELL	1-14-1		
APR.				
APR				

STRESS - STRAIN CURVES
19-9 DL
.125 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A
D2-80096
PAGE 190

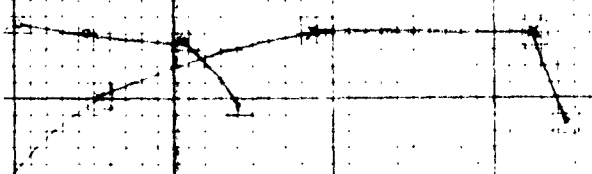
CONTRACT NO



CALC	GUTHRIE
CHECK	GR[illegible]
APR	[illegible]
APR	

DATA SHEET

CONTRACT NO.



SPEC NO.	ENERGY TO ULT. IN-lb/lb	ENERGY TO FAIL. IN-lb/lb
D-10	127,600	150,000
D-11	127,000	138,500
D-12	138,900	146,500

2

STRAIN ≒ IN/IN

← 0.1 →

STRAIN RATE ≒ IN/IN/MIN

180 (TYP)

SPECIMEN NO.	AREA ~SQ.IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
D-10	.0661	111,000	LONG.	72	AIR
D-11	.0667	109,000	LONG.	72	AIR
D-12	.0663	108,400	LONG.	72	AIR

CALC	GUTHRIE	1-27-61	REVISED	DATE	STRESS - STRAIN CURVES 19 - 9DL .125 GAGE SHEET
CHECK	GR[illegible]	1-28-61			
APR	[illegible]	1-28-61			
APR					

X-20A

D2-80086

BOEING AIRPLANE COMPANY

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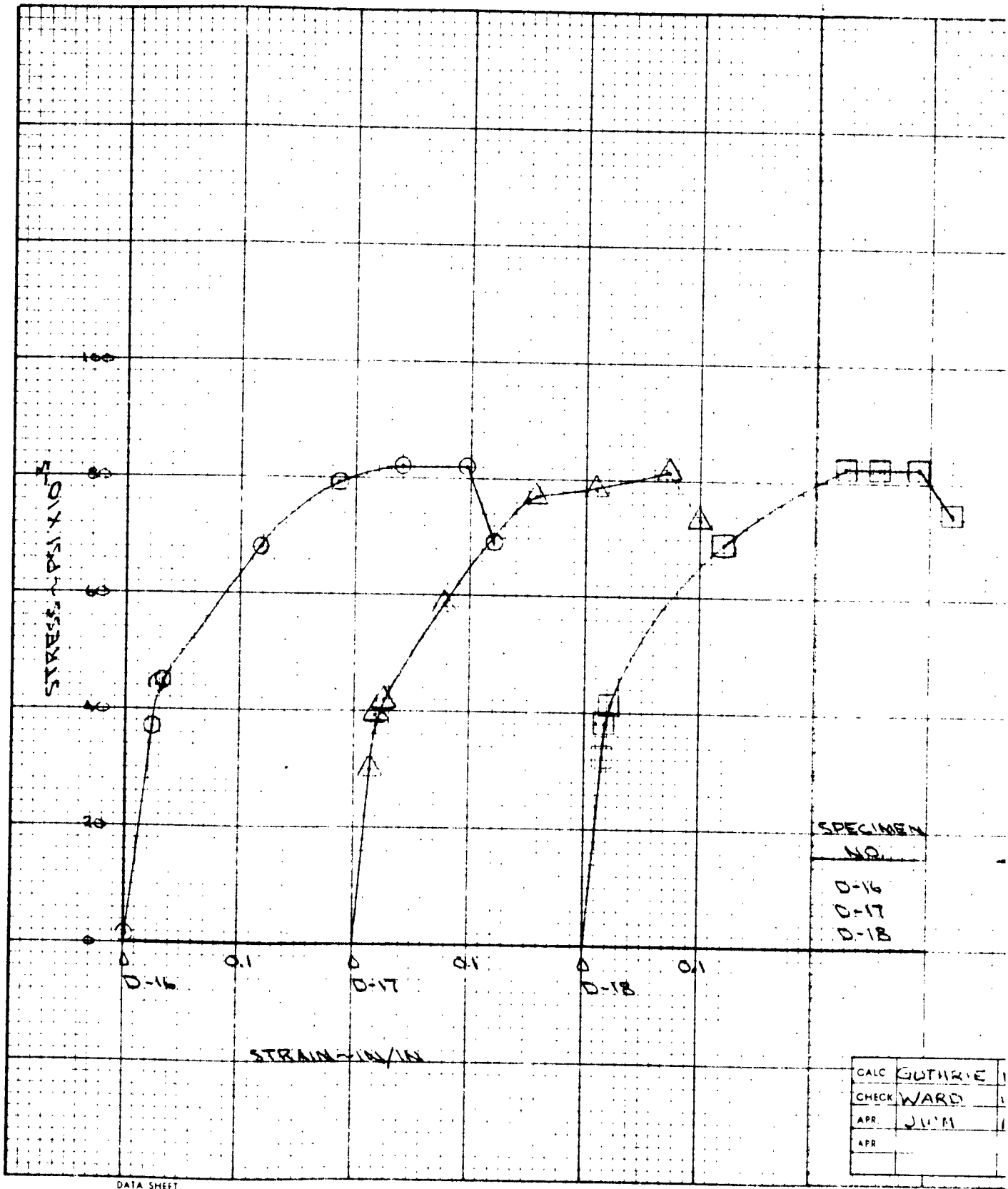
CONTRACT NO.

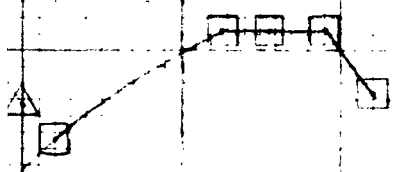


CALC	GUTHRIE
CHECK	WARD
APR.	J.L.M.
APR	

DATA SHEET

U3 4011 5000—REV 7/60 (WAS BAC 360D

CONTRACT NO



SPEC NO	ENERGY TO ULT. IN-LB/LB	ENERGY TO FAIL. IN-LB/LB
D-16	68,200	73,600
D-17	61,000	69,200
D-18	67,400	75,600

2

STRAIN ~IN/IN

← 0.1 →

STRAIN RATE ~IN/IN/MIN

196 (T

SPECIMEN NO.	AREA ~SQ IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP (°F)	TEST ATMOS.
D-16	.0667	82,090	LONG.	600°	AIR
D-17	.0673	81,870	LONG.	600°	AIR
D-18	.0669	82,520	LONG.	600°	AIR

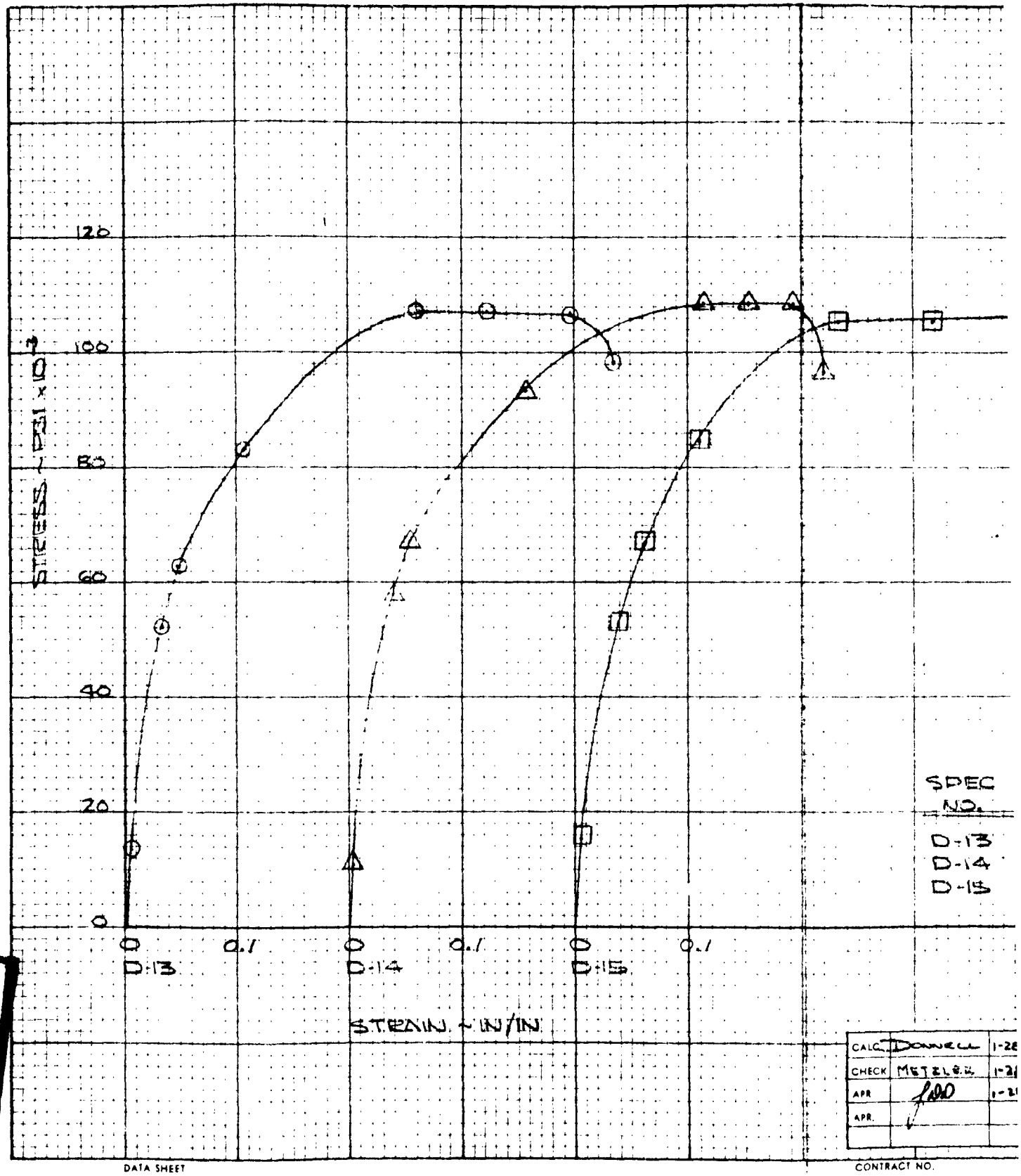
CALC	GUTHRIE	1-27-61	REVISED
CHECK	WARD	1-27-61	DATE
APR.	J.W.M.	1-28-61	
APR			

STRESS STRAIN CURVES
19-9 DL
.125 GAGE SHEET

BOEING AIRPLANE COMPANY

X-20A
D2-80086
PAGE 192

CONTRACT NO

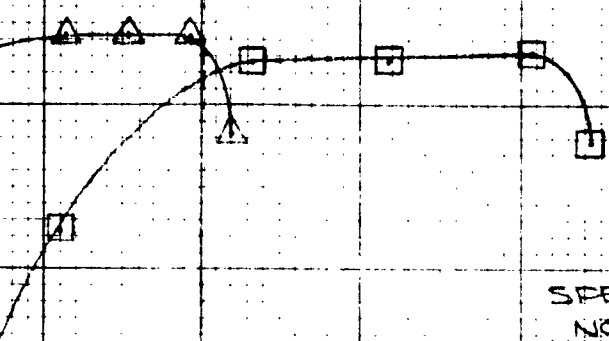


CALC	DONNELL	1-28
CHECK	METZLER	1-2
APR	[illegible]	1-2
APR.		

DATA SHEET

CONTRACT NO.

U3 4011 5000—REV 7/60 (WAS BAC 360)



2

SPEC NO.	ENERGY TO ULT ~IN-LB/IN³	ENERGY TO FAILURE ~IN-LB/IN³
D-13	125,200	140,000
D-14	122,000	132,000
D-15	124,000	141,000

STRAIN IN/IN

STRAIN RATE ~IN/IN/MIN

0.1

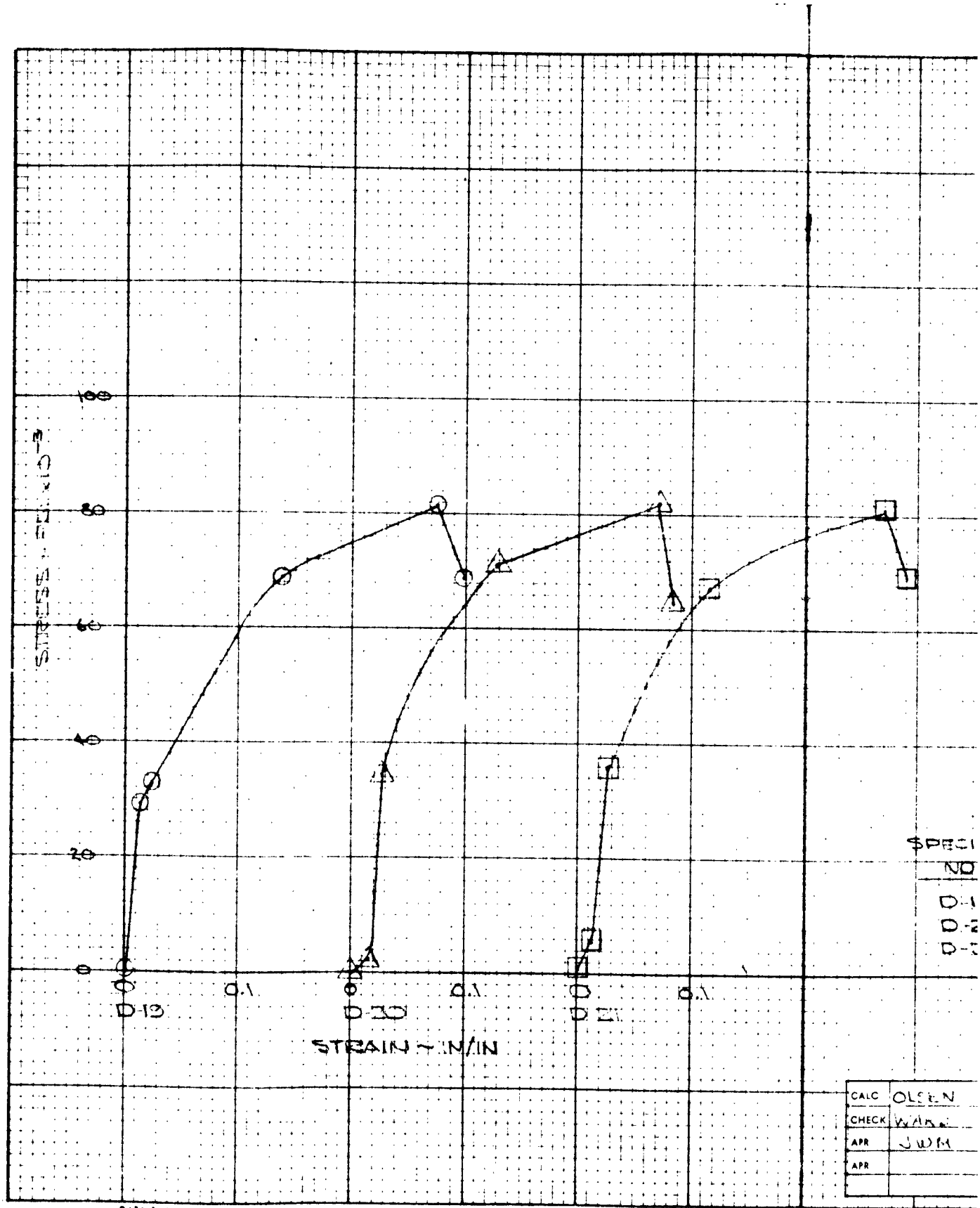
295 TYP.

SPEC NO.	AREA ~SQ.IN.	FTU PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS.
D-13	.0666	107,900	LONG.	72	AIR
D-14	.0663	108,300	LONG	72	AIR
D-15	.0665	106,400	LONG.	72	AIR

0.1

			REVISED	DATE	STRESS-STRAIN CURVES 19-9DL .125 GAGE SHEET	X-20A
CALC	Donnell	1-28-1				D2-30080
CHECK	METZLER	1-28-1			BOEING AIRPLANE COMPANY	PAGE 1-93
APR	[illegible]	1-28-1				
APR.						

CONTRACT NO.



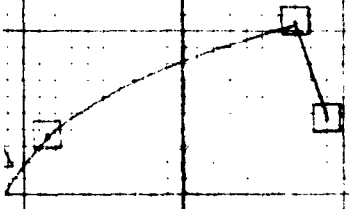
CALC	OLSEN
CHECK	WARNER
APR	JWM
APR	

DATA SHEET

CONTRACT NO

U3 4011 5000—REV 7/60 (WAS BAC 360D)

2



SPEC. NO.	ENERGY TO ULT. - IN-LB/LB	ENERGY TO FAILURE - IN-LB/LB
D-19	58,600	64,300
D-20	58,100	61,500
D-21	58,100	63,000

STRAIN - IN/IN

STRAIN RATE - IN/IN/MIN

0.1

295 (TYP)

SPECIMEN NO.	AREA - SQ. IN.	PTU - PSI	GRAIN DIRECTION	TEST TEMP.	TEST ATMOS.
D-19	.0646	81,700	LONG.	800	AIR
D-20	.0512	82,100	LONG.	800	AIR
D-21	.0663	81,200	LONG.	800	AIR

0.1

CALC	OLSEN	12/61	REVISED	DATE	STRESS-STRAIN CURVES 19-9DL .125 GAGE SHEET
CHECK	WMA	12/61			
APR	JWM	12/61			
APR					

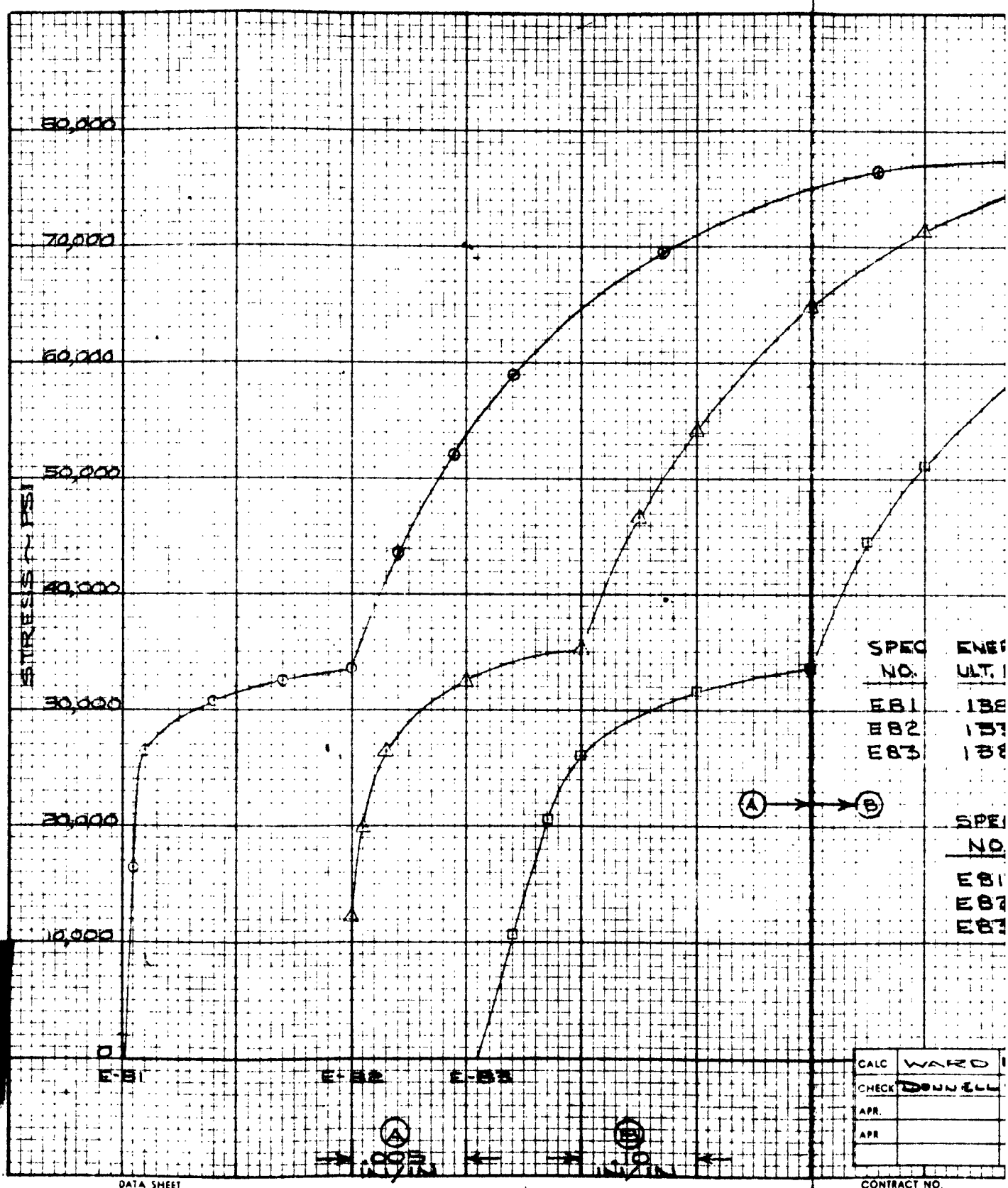
BOEING AIRPLANE COMPANY

X-20A

D2-80086

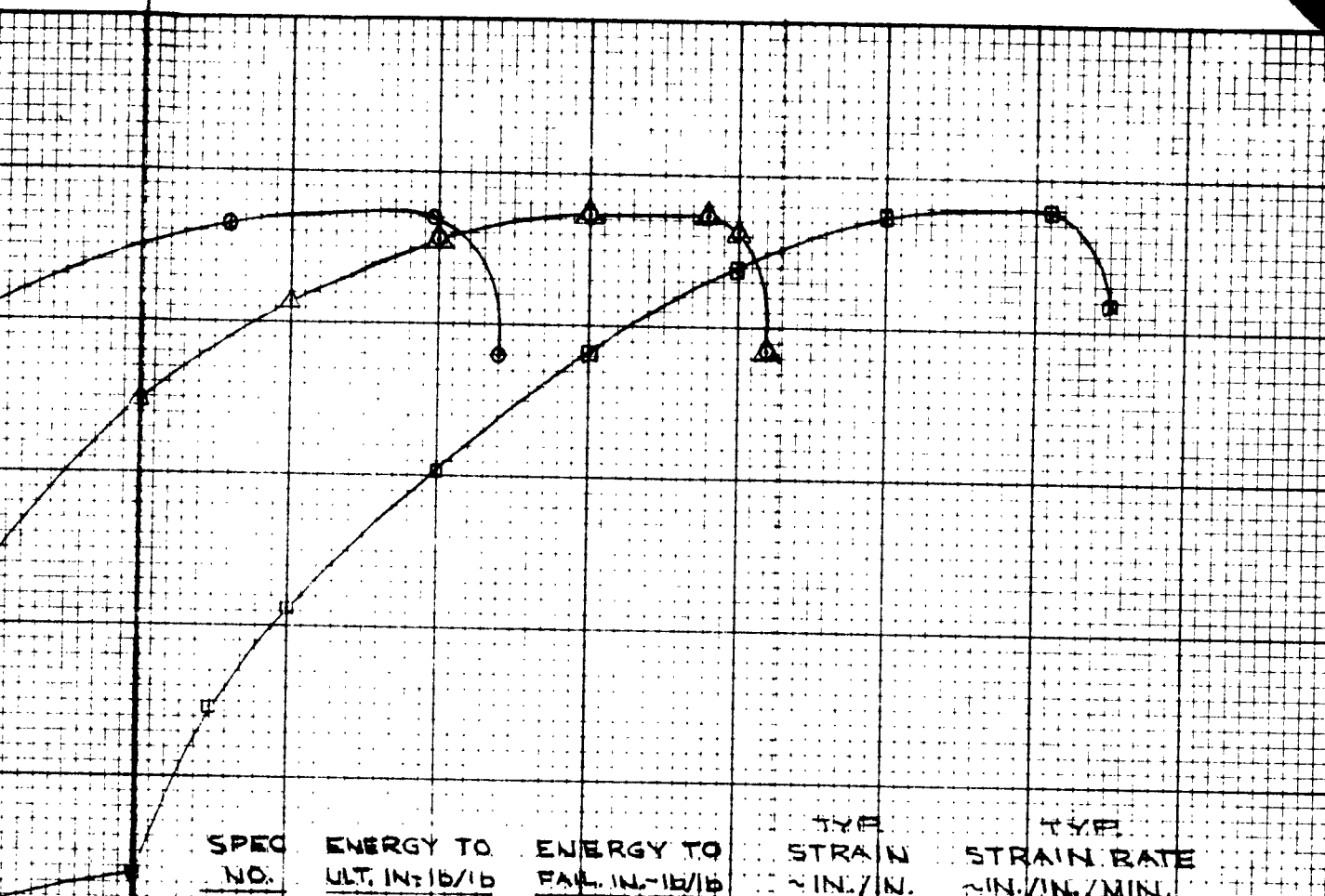
PAGE 694

CONTRACT NO



DATA SHEET

CONTRACT NO.



SPEC NO.	ENERGY TO ULT. IN-lb/lb	ENERGY TO FAIL. IN.-lb/lb	TYP. STRAIN ~IN./IN.	TYP. STRAIN RATE ~IN./IN./MIN.
EB1	138,053	149,103	(A)=.005	(A)=.005
EB2	133,694	144,094		
EB3	138,529	148,529	(B)=.10	(B)=.10

(A) → (B)

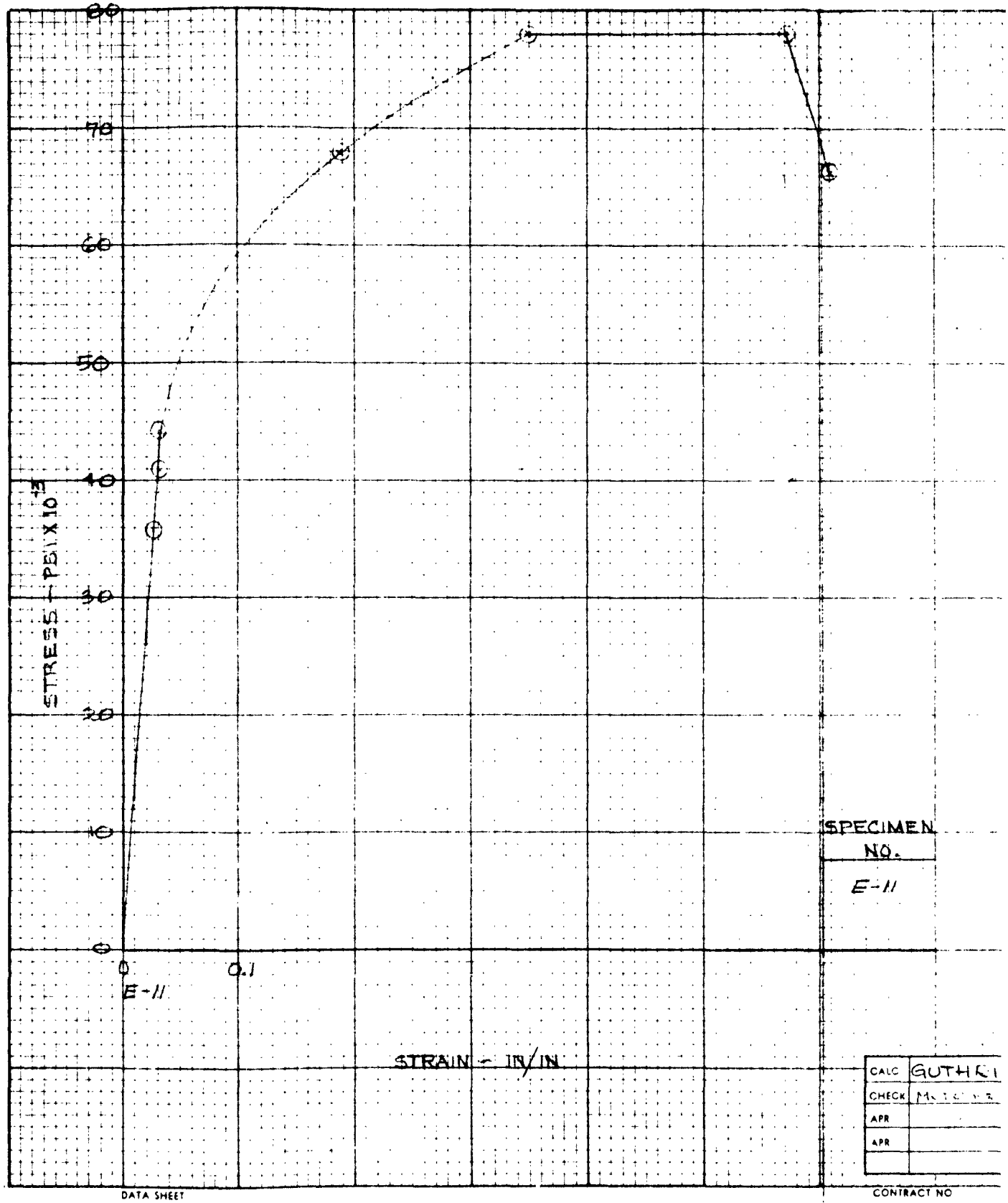
SPEC NO.	AREA ~SQ IN.	ETU ~PSI	GRAIN DIRECT.	TEST TEMP(°F)	TEST ATMOS
EB1	.0563	77,400	LONG.	72	AIR
EB2	.0574	77,400	LONG.	72	AIR
EB3	.0570	78,000	LONG.	72	AIR

2

CALC	WARD 1-4-1	REVISED	DATE	STRESS-STRAIN CURVES 304 ELC .114 GAGE SHEET
CHECK	DONNELL 1-14-1			BOEING AIRPLANE COMPANY
APR.				
APR				

X-20A
D2-80086
1-95

CONTRACT NO.



CALC	GUTHRI
CHECK	[illegible]
APR	
APR	

DATA SHEET

CONTRACT NO

SPEC. NO.	ENERGY TO ULT. IN-lb/lb	ENERGY TO FAIL, IN-lb/lb
E-11	134,500	144,000

2

STRAIN ~IN/IN

← 0.1 →

STRAIN RATE ≈ IN/IN/MIN.

200 (TYP)

SPECIMEN NO.	AREA ~SQ. IN.	ETU ~PSI	GRAIN DIRECTION	TEST TEMP. (°F)	TEST ATMOS.
E-11	.0567	118,000	LONG.	72	AIR

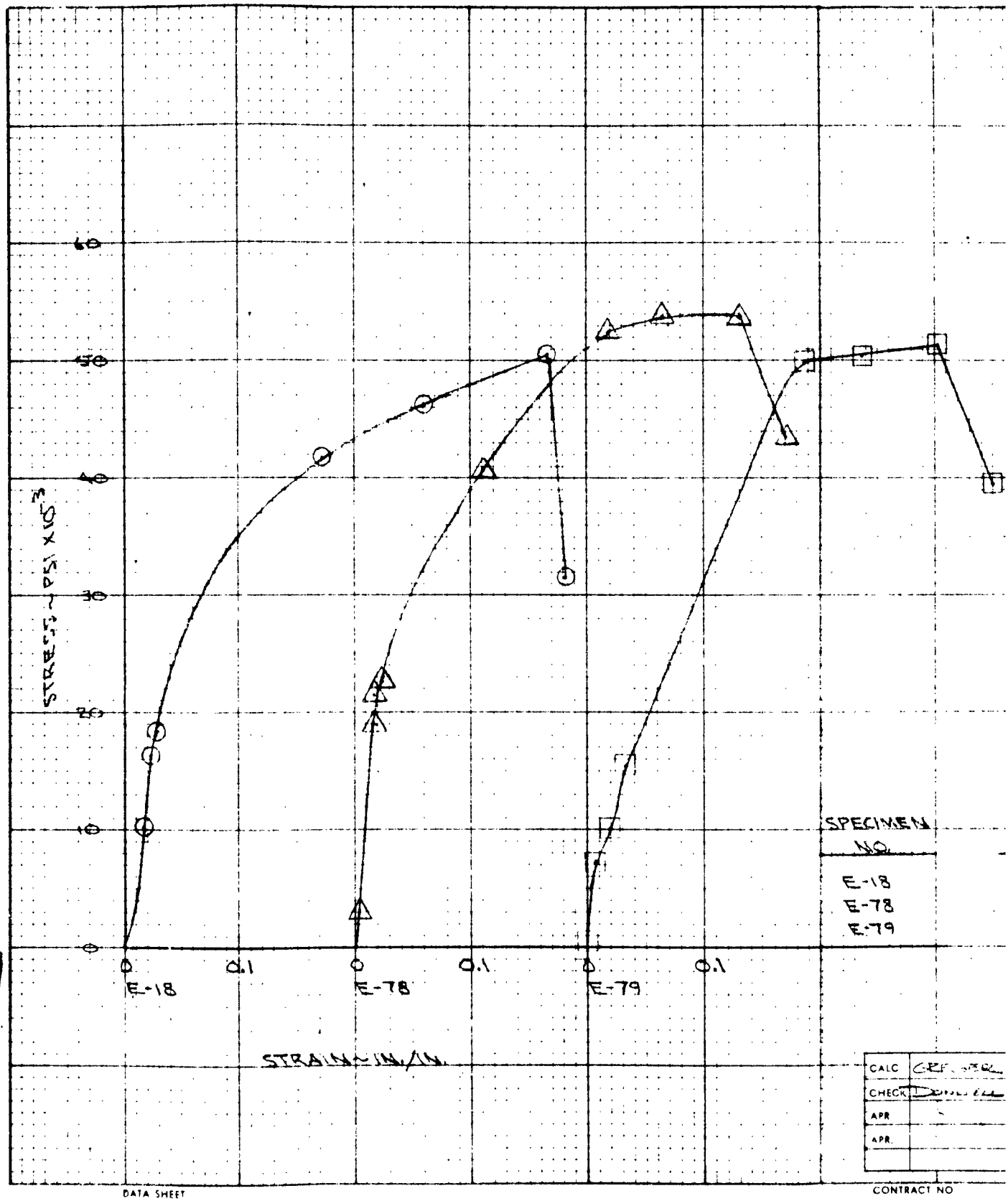
CALC	GUTHRIE 1-27-61	REVISED	DATE	STRESS - STRAIN CURVES 304 ELC .114 GAGE SHEET
CHECK	[illegible]			BOEING AIRPLANE COMPANY
APR				
APR				

X-20A

D2-80086

PAGE 1-96

CONTRACT NO

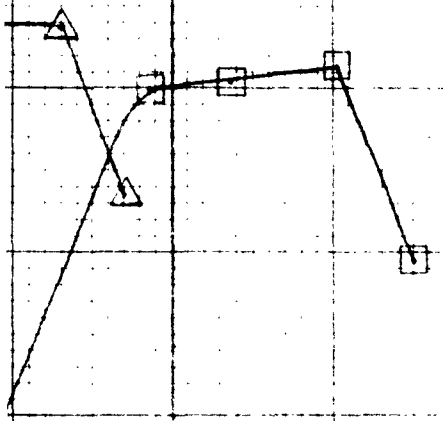


CALC	
CHECK	
APR.	
APR.	

DATA SHEET

CONTRACT NO

U3 401 5000—REV 7/60 (WAS BAC 360D)



SPEC. NO	ENERGY TO ULT. IN-LB/LB	ENERGY TO FAIL IN-LB/LB
E-18	48,500	50,600
E-78	49,160	55,800
E-79	38,900	46,400

STRAIN ~IN/IN

← 0.1 →

STRAIN RATE ~IN/IN/MIN

2.0 (TYP)

SPECIMEN NO.	AREA ~SQ.IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP(°F)	TEST ATMOS.
E-18	.0566	50,500	LONG.	600°	AIR
E-78	.0575	54,000	LONG	600°	AIR
E-79	.0560	51,300	LONG.	600°	AIR

0.1

			REVISED	DATE
CALC	C.R. [illegible]	1-27-1		
CHECK	[illegible]	1-30-1		
APR				
APR				

CONTRACT NO

STRESS-STRAIN CURVES
30A ELC
.114 GAGE SHEET

BOEING AIRPLANE COMPANY

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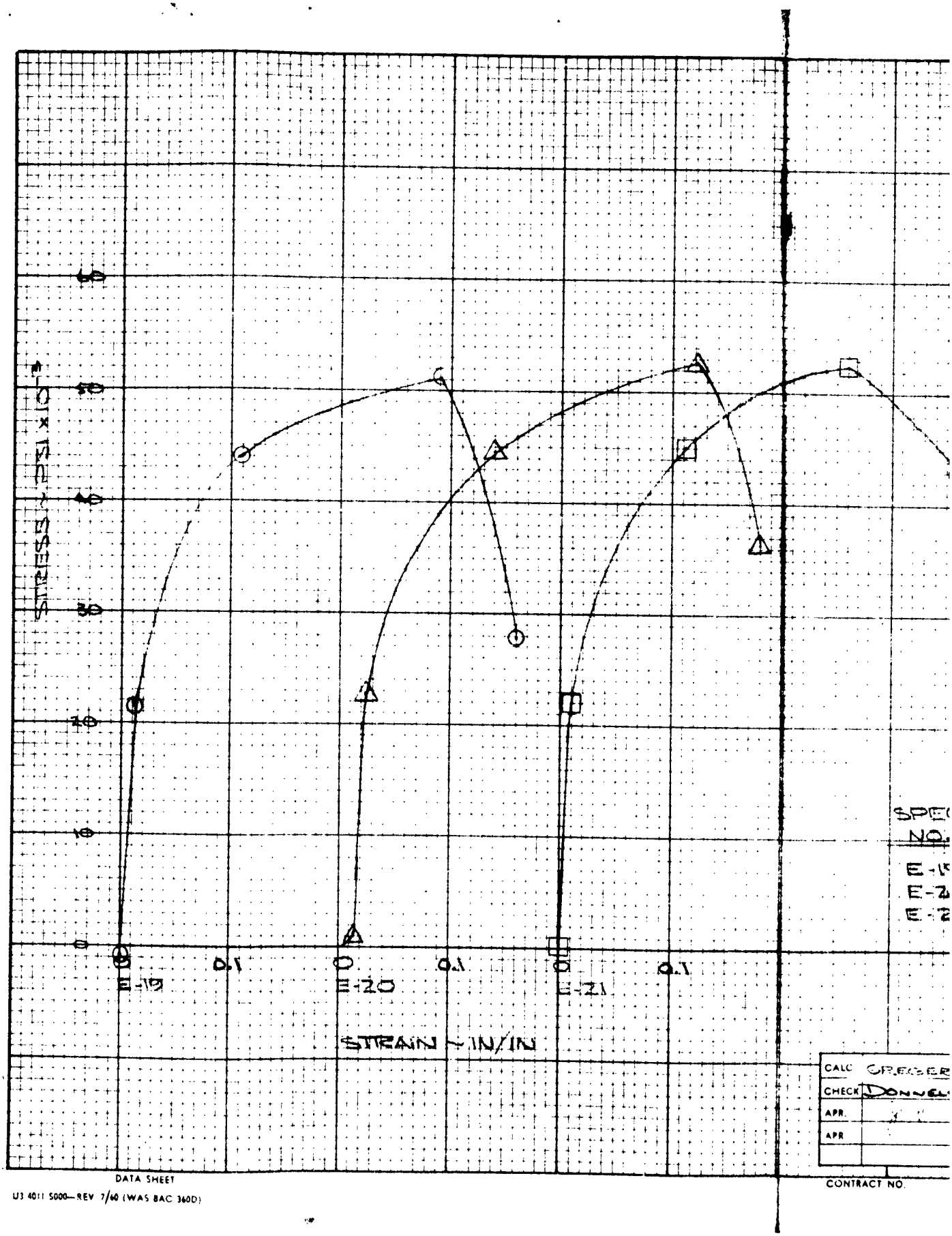
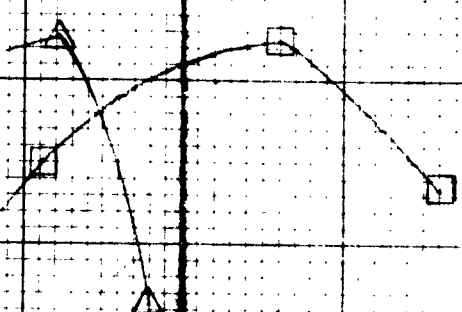


U3 4011 5000—REV 7/60 (WAS BAC 360D)



2

SPEC NO.	ENERGY TO ULT. IN-LB/LB	ENERGY TO FAILURE, IN-LB/LB
E-19	42,300	52,600
E-20	45,900	55,200
E-21	38,800	55,400

STRAIN ~IN/IN

← 0.1 →

STRAIN RATE ~IN/IN/MIN

285 (TYP)

SPEC. NO.	AREA ~SQ IN	FTU ~PSI	GRAIN DIRECTION	TEST TEMP °F	TEST ATMOS
E-19	.0577	51,200	LONG.	800	AIR
E-20	.0569	53,700	LONG.	800	AIR
E-21	.0571	52,500	LONG.	800	AIR

0.1

CALC	GREGORY	1-27-1
CHECK	DONNELL	1-30-1
APR.		
APR		

REVISED	DATE

STRESS-STRAIN CURVES
304 ELC
.114 GAGE SHEET

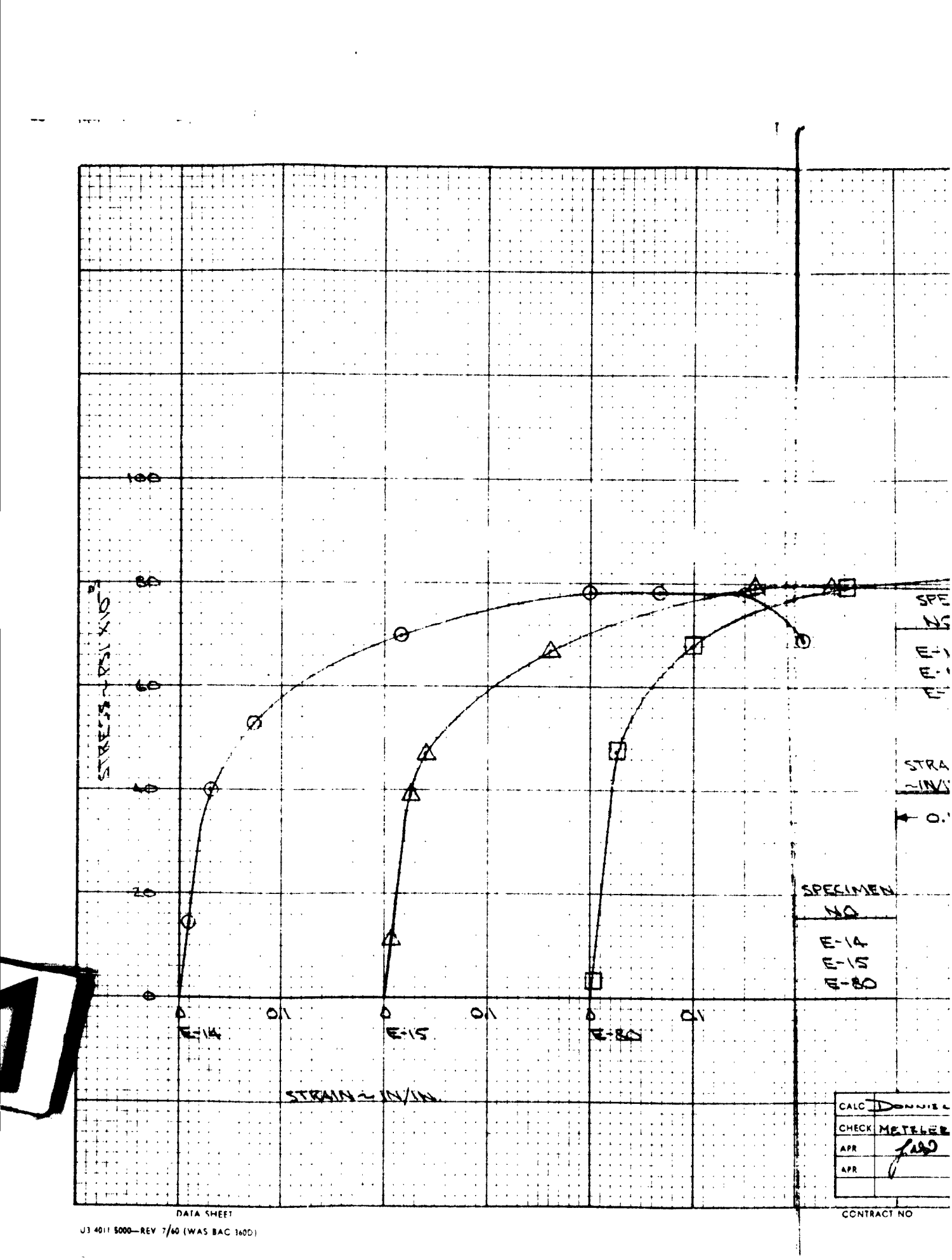
X-20A

D2-80086

BOEING AIRPLANE COMPANY

PAGE 1-98

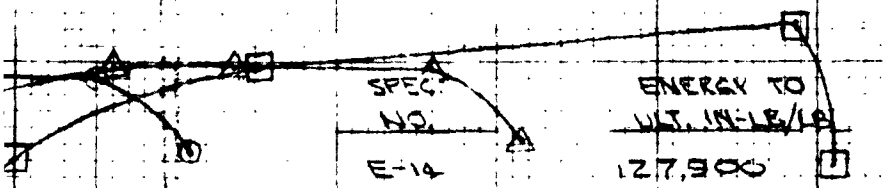
CONTRACT NO



DATA SHEET

CONTRACT NO

U3 4011 5000—REV 7/60 (WAS BAC 3600)



SPEC. NO.	ENERGY TO U.T. IN-LB/LB	ENERGY TO FAIL. IN-LB/LB
E-14	127,900	148,300
E-15	132,900	147,000
E-80	150,000	156,000

2

STRAIN ~IN/IN.

← 0.1 →

STRAIN RATE ~IN/IN/MIN.

300 TYP

SPECIMEN NO	AREA ~SQ.IN.	FTU ~PSI	GRAIN DIRECTION	TEST TEMP.(°F)	TEST ATMOS.
E-14	.0558	78,100	LONG.	72°	AIR
E-15	.0557	79,950	LONG.	72°	AIR
E-80	.0565	84,900	LONG.	72°	AIR

			REVISED	DATE
CALC	DONNELL	1-28-1		
CHECK	METZLER	1-28-1		
APR	[illegible]	1-28-1		
APR				

STRESS-STRAIN CURVES
304 ELC
.114 GAGE SHEET

X-20A

D2-60086

PAGE 199

BOEING AIRPLANE COMPANY

CONTRACT NO

THE BOEING COMPANY

NUMBER D2-80086 MODEL NO. X-20

TITLE Main Landing Gear Energy System Development

PREPARED BY	J. Grant J. Grant	5/27/63
SUPERVISED BY	Roy Logan R. R. Logan	5/27/63
APPROVED BY	Ken Baber K. Baber	5-27-63 , A.K. Hepler 6/7/63
RELIABILITY APPROVAL	R. Kwaigood	5-27-63 (DATE)

AF33(657)-7132
CONTRACT NO.

5-76200-5590-05638-3-25353
CHARGE NUMBER

2-5142

SECTION TITLE PAGE U3 4288 0000 REV. V61

98

2.1 SUMMARY

2.1.1 This report contains the results of impact and static load testing of ten (10) main landing gear energy strap test specimens (full-scale) and three (3) standard tensile specimens, all fabricated from the same heat of Inconel material.

2.1.2 The impact tests were conducted at specimen temperatures and impact velocities simulating three landing sink rates. Ten full-scale specimens were impact tested.

2.1.3 The static load tests were conducted at room temperature to determine the maximum energy absorbing capacity of the previously impact tested specimens and to determine the static tensile properties of the material.

2.1.4 Impact test results obtained included specimen load and deflection versus time curves, permanent angular displacement of the specimen pivot end due to strap terminal-pin friction, and specimen elongation and section change over the specimen length.

2.1.5 Static test results obtained included load versus deflection curves for the two (2) energy strap specimens and load versus strain curves for the three (3) standard tensile specimens.

2.2 TABLES OF CONTENTS

2.3 REFERENCES

2.3.1	Main Landing Gear Energy System Development		EWA 5638 [1]
2.3.2	Energy Strap (D/S) Installation (Test Only)		BAC 25-80333
2.3.3	Strap-Shock Absorber Main Landing Gear (Test Only)		BAC 29-80001
2.3.4	Tensile Specimen Round		BAC 23-7070
2.3.5	Energy Strap Test Specimen, Figure 2.4	Neg. No.	FA-2A94975
2.3.6	Energy Strap Pivot End, Figure 2.5	Neg. No.	FA-2A94977
2.3.7	Pivot End Rene' 41 Pin, Figure 2.6	Neg. No.	FA-2A100490
2.3.8	Quick Release Mechanism, Figure 2.7	Neg. No.	FA-2A95785
2.3.9	Pivot End Test Fixture, Figure 2.8	Neg. No.	FA-2A100945
2.3.10	Impact Test Setup, Figure 2.10	Neg. No.	FA-2A102524
2.3.11	Impact Test Setup, Figure 2.11	Neg. No.	FA-2A102115

[1] Refer to D2-6783-1 Structural Integrity Development and Test Program - Detail Plan - Structures Technology

2.4 INTRODUCTION

2.4.1 This report is the result of work accomplished on EWA 9638;* Reference 2.3.1. This work was required to obtain energy-absorbing characteristics of a proposed main landing gear energy strap configuration, fabricated from Inconel material, over the applicable range of landing temperatures and dynamic loading rates.

* Refer to D2-6783-1 Structural Integrity Development and Test Program - Detail Plan - Structures Technology

2.5 TEST SPECIMEN

2.5.1 The ten (10) main gear energy strap impact load test specimens were fabricated per Reference 2.3.3. A sketch of the test specimens is shown on Pages 2-15 thru 2-18.

2.5.2 The five (5) static load test specimens consisted of two (2) of the previously impact-tested specimens, and three (3) standard tensile specimens fabricated per Reference 2.3.4. A sketch of the tensile test specimens is shown in Figure 2.2.

2.5.3 All test specimens were fabricated from the same heat of 2 3/8" diameter Inconel bar, annealed at 1875 ±25°F for 30 minutes after machining, and then air cooled.

2.6 TEST SETUP AND INSTRUMENTATION

2.6.1 The impact load test setup utilized a falling weight dropped from a predetermined height (based on initial strap impact velocity requirement) onto the lower part of the test fixture, which was covered with a one inch layer of high density styrofoam. The styrofoam layer had a compressive yield strength of 120 to 140 PSI and acted as a shock absorber. The induced load was transmitted by the test fixture to the pivot beam. The pivot beam, in turn, transferred the load through a Rene' 41 pivot pin to the terminal of the energy strap specimen. As the energy strap deflected or elongated under the impact load application, the pivot beam rotated through an angle of rotation that simulates movement between the energy strap and the landing gear strut during a landing impact condition. The impact test setup is shown on Pages 2-20 thru 2-24.

2.6.2 The impact load test elevated temperature environment was obtained by surrounding the strap specimen with twelve (12) radiant heat lamps. These heat lamps were powered and controlled by an ignitron unit.

2.6.3 The impact load test instrumentation consisted of an electronic deflection indicator and a load cell to measure deflection and impact load and an oscillograph to record the load and the deflection with a common time base. A high-speed camera and a Vanguard Analyzer were used to calibrate and check the oscillograph deflection recording during the early phase of testing. Eight (8) spot-welded chromel-alumel thermocouples, equally spaced along the length of each specimen, were used to measure specimen temperatures.

2.6.4 The static load test specimens were tested in a 120,000-pound capacity Baldwin Universal Test Machine. The machine was equipped with a Model MD-2 Autographic Load Strain Recorder. A Baldwin Strain Pacer was used to insure a proper average strain rate. The strain to failure was measured using a Baldwin TS-MD Dual-Range Extensometer. All static tests were conducted at room temperature.

2.7 TEST PROCEDURE

2.7.1 In order to satisfy the required strap impact test parameters, as tabulated in Table 2.1, Page 2-8, several trial runs were conducted with simulated test specimens installed in the test system. The strap load-deflection data obtained from these runs were used to determine the energy-output characteristics of the test system.

2.7.2 The actual specimen being impact-tested was then placed in the test setup, using a new oxidized Rene' 41 pin for each test to simulate actual operating condition. The specimen was brought to the required stabilized temperature over the specimen length, the weight was dropped and the following data obtained:

1. Strap load versus time.
2. Strap elongation versus time.
3. Angular displacement of the strap pivot end.
4. Elongation of measured sections along the strap length.
5. Change of diameters at various sections along the strap length.

2.7.3 The static test specimens were placed in a Universal Test Machine and tested to failure. Strain versus load was recorded for the tensile round specimens, and load versus deflection was recorded for the previously impact-tested specimens.

2.8 TEST RESULTS

2.8.1 Maximum impact strap load, impact strap energy and strap per cent elongation are tabulated on Pages 2-9 thru 2-11. Angular displacement of the pivot end is shown on Page 2-12. Load versus time, deflection versus time, and load versus deflection curves are shown on Pages 2-25 thru 2-42.

2.8.2 Static test results showing ultimate and yield strength are tabulated on Pages 2-13 and 2-14 . Static load versus deflection curves for the impact-tested specimens are shown on Page 2-43. Static load versus strain curves for the standard tensile specimens are shown on Pages 2-44 thru 2-46.

2.9 TEST OBSERVATIONS

2.9.1 All impact load tests were completed satisfactorily with the exception of the impact test on specimen number three. No data was obtained for this specimen due to premature release of the drop weight.

2.9.2 The five (5) specimens static tested in the Baldwin Universal Test Machine were completed satisfactorily.

TABLE 2.1

REQUIRED IMPACT TEST PARAMETERS
(REFERENCE 2.3.1)

Temperature °F	72	300	600	600	600
Gear Impact Velocity FT/SEC	10	10	4	7	10
Strap Impact Velocity FT/SEC	20.8	20.8	8.3	14.6	20.8
Strap Energy Input FT-LB	10,900	10,900	1,740	5,300	10,900

TABLE 2.1

REQUIRED IMPACT
TEST PARAMETERS

PART NO.				
SPECIMEN NO.		1	2	3
TEST RESULTS				
TEMP. - °F	2	72	72	APPX 100
WEIGHT DROPPED LBS.	2	1562	1762	1762
DISTANCE OF DROP INCH	2	82	86	86
STRAP IMPACT VEL - FT/SEC.	3	20.8	20.8	20.8
STRAP IMPACT VEL - FT/SEC.	4	21.0	21.5	21.5
STRAP DEFLECTION (MAX.) INCH	2	5.6	7.0	5.8 MEASUI
ANGULAR ROTATION OF PIVOT BEAM ($\propto$) DEG.	5 4	21.0	27.0	—
TOTAL INPUT ENERGY OF THE SYSTEM FT-LB.	6 4	11,700	13,950	—
STRAP ENERGY INPUT (RECORDED) FT-LBS.	6 1 4	7,800	9,980	—
STRAP MAX. IMPACT LOAD - KIPS	3	21.0	22.3	—

1 > STRAP ENERGY INPUT WAS OBTAINED FROM THE AREA UNDER THE LOAD-DEFI

2 > MEASURED DATA

3 > REQUIRED DATA (SEE TABLE 2.1)

4 > CALCULATED DATA AS FOLLOWS:

$$V = \sqrt{2gH/6}$$

$$E_{CAL} = \frac{W_1H+(W_1+W_2)\Delta}{12}$$

WHERE V - IS THE VELOCITY OF THE FALLING BODY AT IMPACT.
H - IS THE DISTANCE THE FALLING BODY WILL DROP BEFORE IMPACT.
E_{CAL} - IS THE TOTAL INPUT ENERGY OF THE SYSTEM
W_1 - IS THE WEIGHT OF THE FALLING BODY.
W_2 - IS THE WEIGHT OF THE TEST FIXTURE.
Δ - IS THE DEFLECTION OF THE TEST SPECIMEN.

5 > SEE PAGE 2-22 FOR LOCATION OF ANGLE ($\propto$)

6 > THE ENERGY LOSS IN THE SYSTEM WAS DUE TO THE FOLLOWING:
1) FRICTION BETWEEN THE FALLING WEIGHT AND THE TEST FIXTURE. (AND)
2) CRUSHING OF THE STYROFOAM LAYER ON THE TEST FIXTURE BASE PLATE AT IMPACT.

1

CALC	
CHECK	
APR	
APR	

MAIN GEAR ENERGY STRAPS

	29-80001-3									
	1	2	3	4	5	6	19	20	21	22
V	72	72	APPX. 100	300	300	600	600	600	600	600
V	1562	1762	1762	1762	1762	1762	1855	1855	1855	1855
V	82	86	86	86	86	86	14.7	14.7	42.5	42.5
V	20.8	20.8	20.8	20.8	20.8	20.8	8.3	8.3	14.6	14.6
V	21.0	21.5	21.5	21.5	21.5	21.5	8.75	8.75	14.8	14.8
V	5.6	7.0	5.8 MEASURE	7.78	7.94	8.68	2.50	2.63	5.34	5.71
V	21.0	27.0	—	30.7	31.3	34.4	10.2	10.8	22.0	23.5
V	11,700	13,950	—	14,110	14,140	14,282	2764	2789	7620	7692
V	7,800	9,980	—	10,460	10,096	11,160	1815	2148	5188	5854
V	21.0	22.3	—	21.3	20.2	20.9	11.4	12.2	15.9	15.7

ON THE AREA UNDER THE LOAD-DEFLECTION CURVE ON PAGE 2-25 THRU 2-42

2

Y AT IMPACT.
ILL DROP BEFORE IMPACT.
YSTEM

DMEN.

E (∝)

DUE TO

WEIGHT AND THE

ER ON THE TEST

CALC J.Lobo		REVISED	DATE	TABLE 2.2 IMPACT TEST RESULTS X-20 MAIN LANDING GEAR		X-20
CHECK						D2-80086
APR						
APR				THE BOEING COMPANY		PAGE 2-9

SPECIMEN NO.		'A' [1]	'B' [1]	'C' [1]	'D' [1]	'E' [1]	'F' [1]	'G' [1]	'H' [1]
1	DISTANCE	[2]	—	—	—	—	—	—	—
	% DIFF.								
2	DISTANCE	[2]	—	—	—	—	—	—	—
	% DIFF								
3	DISTANCE	[2]	—	—	—	—	—	—	—
	% DIFF.								
4	DISTANCE	—	—	6.00	6.00	6.00	6.00	6.00	6.00
	% DIFF.			+17.7	+17.7	+17.7	+17.7	+17.7	+17.7
5	DISTANCE	2.90	5.72	5.72	5.72	5.72	5.72	5.72	5.72
	% DIFF.	+9.3	+18.01	+18.01	+18.01	+18.01	+18.01	+18.01	+18.01
6	DISTANCE	3.00	5.50	5.50	6.00	6.00	6.00	6.00	6.00
	% DIFF.	+5.0	+11.3	+11.3	+19.8	+19.8	+19.8	+19.8	+19.8
19	DISTANCE	3.00	5.50	5.50	5.50	5.50	5.50	5.50	5.50
	% DIFF.	+4.0	+6.9	+6.9	+6.9	+6.9	+6.9	+6.9	+6.9
20	DISTANCE	3.00	5.50	5.50	5.50	5.50	5.50	5.50	5.50
	% DIFF.	+4.0	+4.5	+6.7	+6.7	+6.7	+6.7	+6.7	+6.7
21	DISTANCE	3.00	5.50	5.50	5.50	5.50	5.50	5.50	5.50
	% DIFF.	+2.0	+12.0	+12.0	+12.0	+12.0	+12.0	+12.0	+12.0
22	DISTANCE	3.00	5.50	5.50	5.50	5.50	5.50	5.50	5.50
	% DIFF.	+2.0	+12.6	+12.6	+12.6	+12.6	+12.6	+12.6	+12.6

[1] FOR MEASURMENT LOCATION SEE FIGURE 2.3

[2] DATA NOT RECORDED FOR SPECIMENS 1, 2, AND 3.

$$\% \text{ DIFF} = \frac{\text{CHANGE OF SECTION LENGTH}}{\text{ORIGINAL LENGTH OF SECTION}}$$

CALC	Grant	5/1/3	REVISED	DATE
CHECK	[illegible]			
APR				
APR				

TABLE 2.3

MAIN GEAR ENERGY STRAP SECTION LENGTHS AND PERCENT ELONGATION AFTER IMPACT TEST

THE BOEING COMPANY

X-20

D2-80086

U3 4041 0000

107

SPECIMEN NO		'A1' [1]	'B1' [1]	'C1' [1]	'D1' [1]	'E1' [1]	'F1' [1]	'G1' [1]	'H1' [1]
1	DIAMETER	[2]	—	—	—	—	—	—	—
	% DIFF.								
2	DIA.	[2]	—	—	—	—	—	—	—
	% DIFF.								
3	DIA.	[2]	—	—	—	—	—	—	—
	% DIFF.								
4	DIA.	—	.671	.669	.668	.668	.667	.665	.663
	% DIFF.		-7.90	-7.77	-7.63	-7.78	-8.10	-8.27	-7.24
5	DIA.	.6635	.669	.6685	.669	.669	.668	.6685	.6735
	% DIFF	-7.76	-8.07	-7.93	-7.70	-8.07	-8.38	-8.15	-6.90
6	DIA.	.668	.669	.666	.669	.664	.668	.669	.676
	% DIFF.	-8.23	-8.37	-8.56	-8.22	-8.43	-8.08	-8.82	-4.88
19	DIA.	.664	.666	.665	.670	.670	.670	.670	.670
	% DIFF.	-2.26	-2.40	-2.26	-2.69	-2.84	-2.69	-3.14	-2.24
20	DIA.	.665	.667	.667	.667	.668	.669	.669	.667
	% DIFF.	-2.26	-2.85	-2.85	-2.70	-2.84	-2.99	-3.14	-2.55
21	DIA.	.664	.667	.666	.666	.670	.665	.667	.669
	% DIFF.	-4.82	-5.40	-5.11	-5.56	-5.22	-5.71	-5.85	-4.78
22	DIA.	.665	.666	.667	.664	.666	.666	.665	.665
	% DIFF.	-4.96	-5.71	-5.85	-5.57	-6.16	-5.71	-6.17	-4.96

[1] FOR MEASURMENT LOCATION SEE FIGURE 2.3

[2] DATA NOT RECORDED FOR SPECIMENS 1,2,AND 3.

$$\% \text{ DIFF} = \frac{\text{CHANGE OF SECTION DIAMETER}}{\text{ORIGINAL DIAMETER OF SECTION}}$$

CALC	Grant	5/1/[illegible]	REVISED	DATE
CHECK	Anderson			
APR				
APR				

TABLE 2.4
MAIN GEAR ENERGY STRAP DIAMETER AND PER-CENT CHANGE AFTER IMPACT TEST.

THE BOEING COMPANY

X-20

D2-80086

10f

SPECIMEN NO.	ANGLE θ (DEGREES)	DEFLECTION "A" (INCHES)
1	—	—
2	7.8	.23
3	—	—
4	5.3	.15
5	6.0	.16
6	7.0	.21
19	1.7	.094
20	3.0	.13
21	8.8	.28
22	7.0	.24

DATA NOT RECORDED

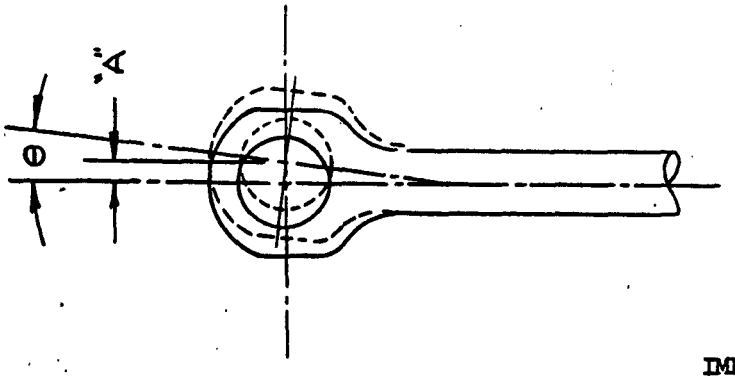


TABLE 2.5

IMPACT TEST RESULTS
PERMANENT ANGULAR DISPLACEMENT
OF STRAP PIVOT END

TABLE 2.6

SPECIMEN NUMBER	SPECIMEN LENGTH BEFORE IMPACT TEST (INCHES)	SPECIMEN LENGTH BEFORE STATIC TEST (INCHES)	FINAL LENGTH AFTER STATIC TEST (INCHES)	TEMP. °F	DEFLECTION RATE (IN/MIN)
1	45.50	51.1	63.1	Room	1.5
3	45.50	51.3	62.7	Room	4.0

SPECIMEN NUMBER	ENERGY ABSORBED DURING IMPACT TEST (FT-LBS)	ENERGY ABSORBED DURING STATIC TEST (FT-LBS)	TOTAL ENERGY ABSORBED (FT-LBS)
1	7,800	25,420	33,200
3	[1]	25,830	———

PREVIOUSLY IMPACT TESTED STRAP SPECIMEN
(REFERENCE PAGE 2-44 FOR STATIC TEST DATA)

[1] DATA NOT RECORDED

TABLE 2.6
STATIC TEST RESULTS

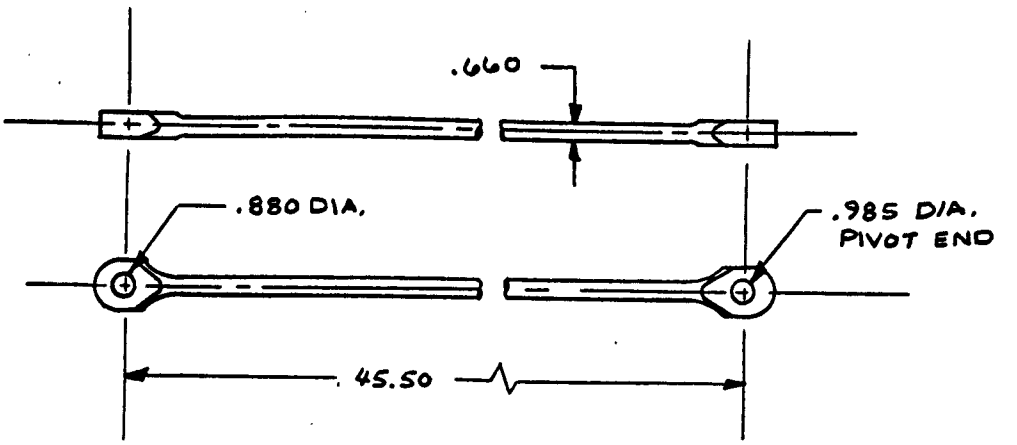
TABLE 2.7

SPECIMEN NUMBER	ATMOSPHERE	GRAIN DIRECTION	TEST TEMP. (°F)	ULTIMATE STRENGTH (PSI)	YIELD STRENGTH (PSI)	ELONGATION % PER 2 INCHES
2-1	Air	Long-itudinal	Room	84,100	25,000	53
2-2	Air	Long-itudinal	Room	83,300	23,800	52
2-3	Air	Long-itudinal	Room	83,100	23,800	54

STANDARD TENSILE ROUND TEST SPECIMENS
(REFERENCE PAGES 2-44 THRU 2-46.)

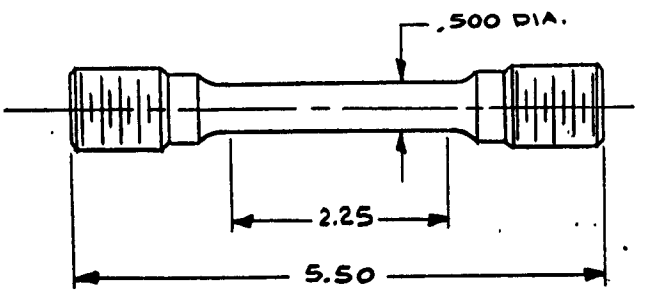
TABLE 2.7
STATIC TEST RESULTS

FIGURE 2.1



STRAP SHOCK ABSORBER MAIN LANDING GEAR
SPECIMEN NUMBER 29-80001-3

FIGURE 2.2



TENSILE SPECIMEN ROUND
SPECIMEN NUMBER 23-7070

FIGURE 2.1 & 2.2
TEST SPECIMEN

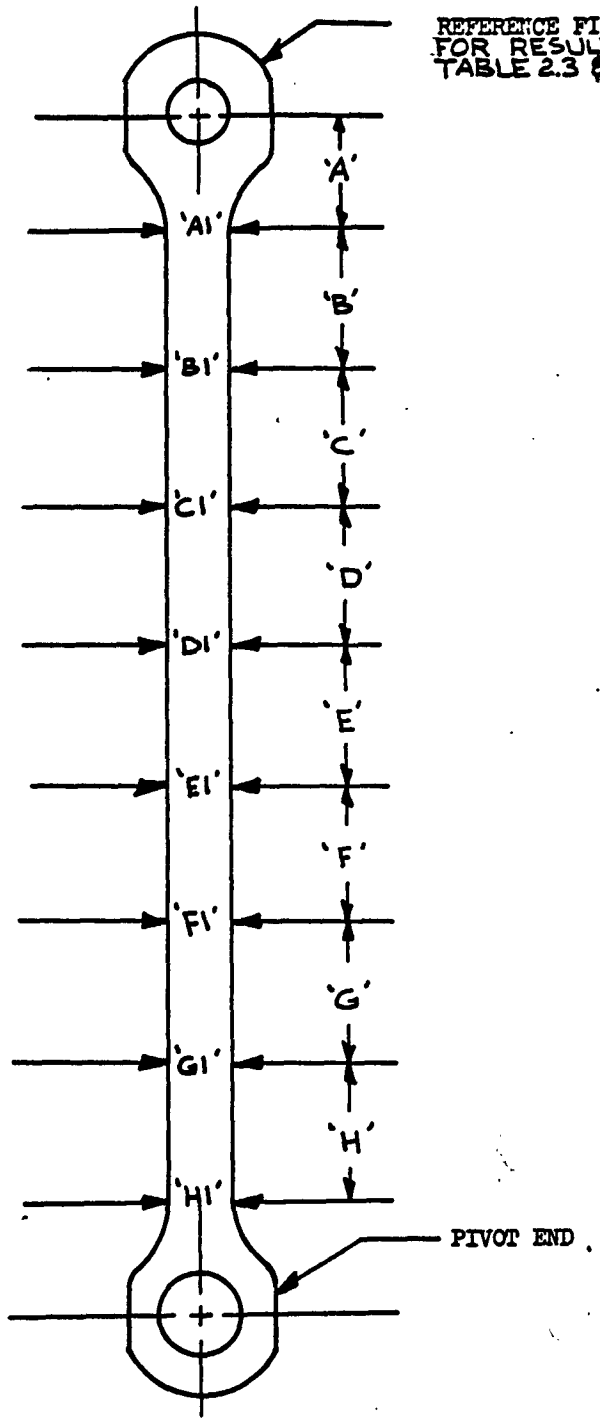


FIGURE 2.3

SECTION ELONGATION AND DIAMETER MEASUREMENT LOCATION (SKETCH)

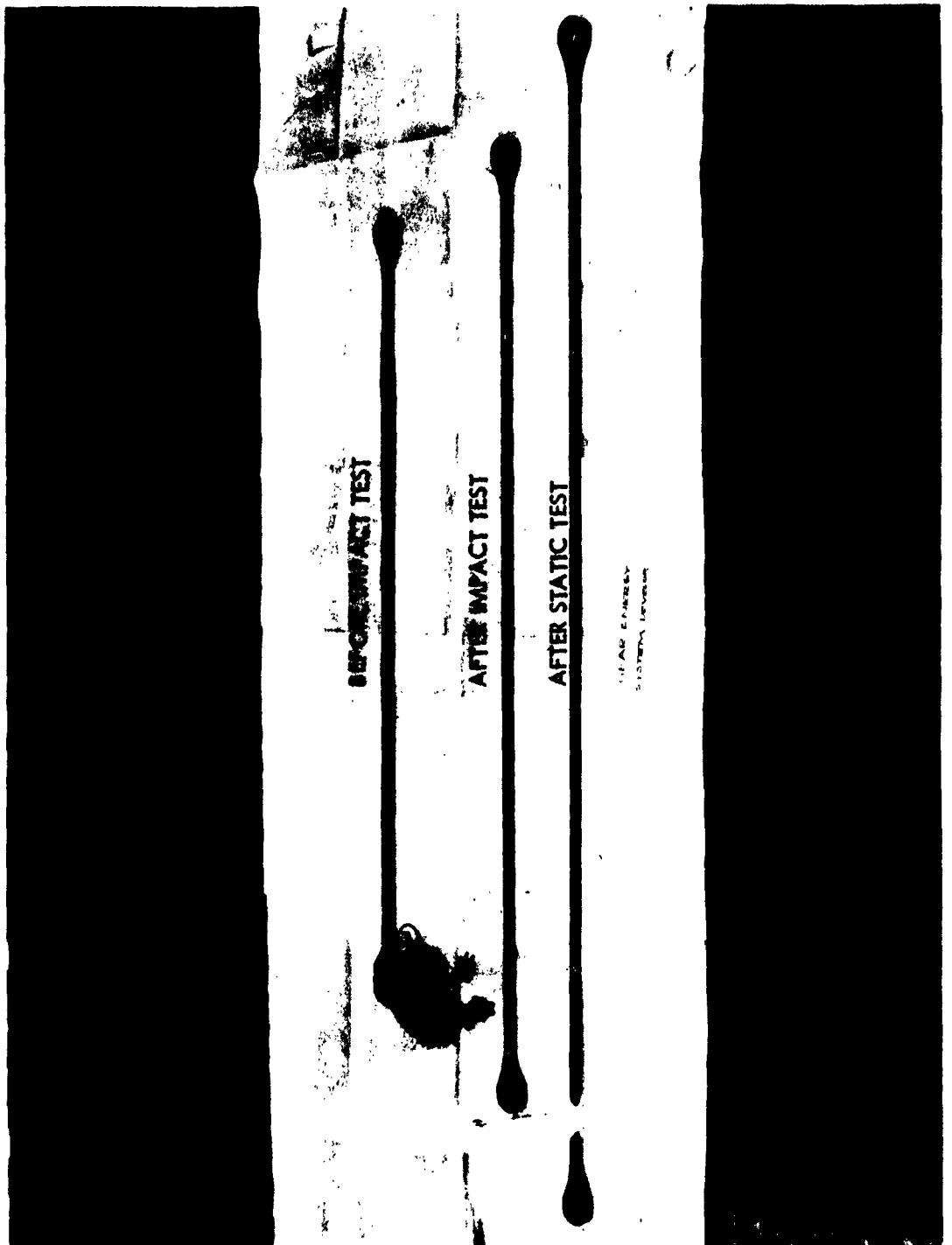


FIGURE 2.4
TYPICAL ENERGY STRAP
TEST SPECIMEN

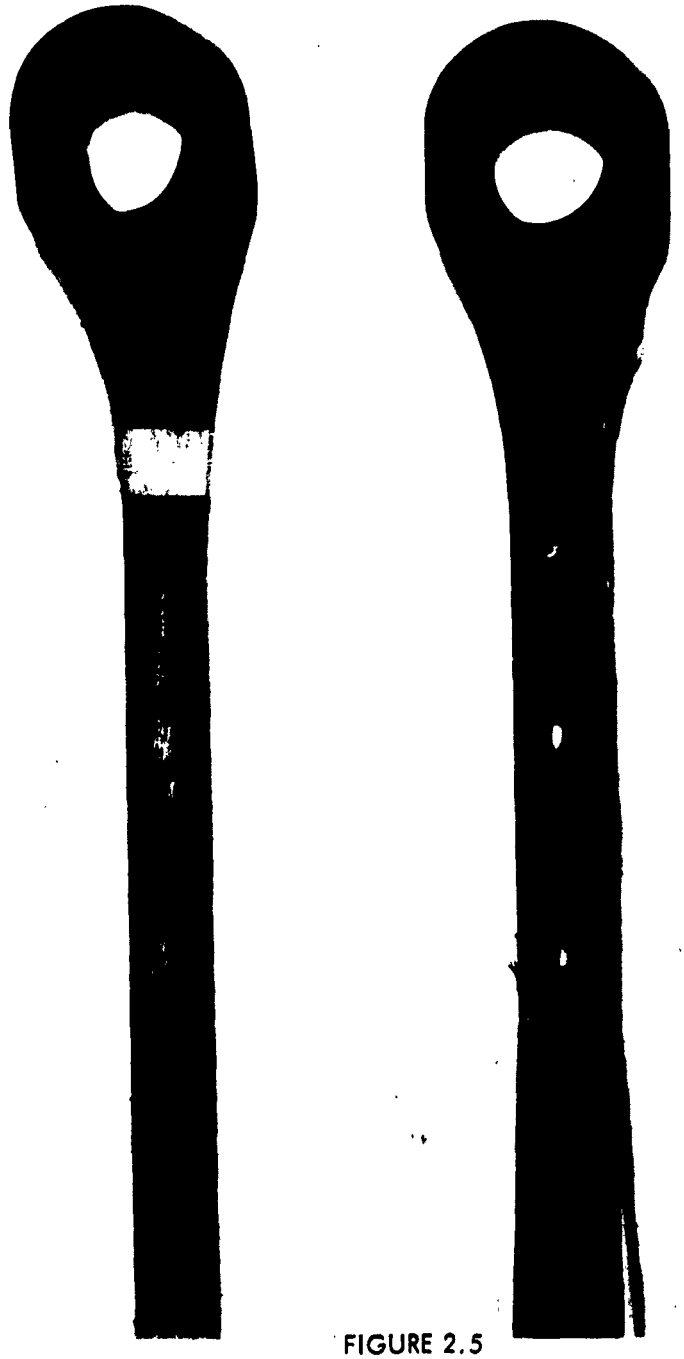


FIGURE 2.5
TYPICAL ENERGY STRAP
PIVOT END

BEFORE IMPACT TEST AFTER IMPACT TEST

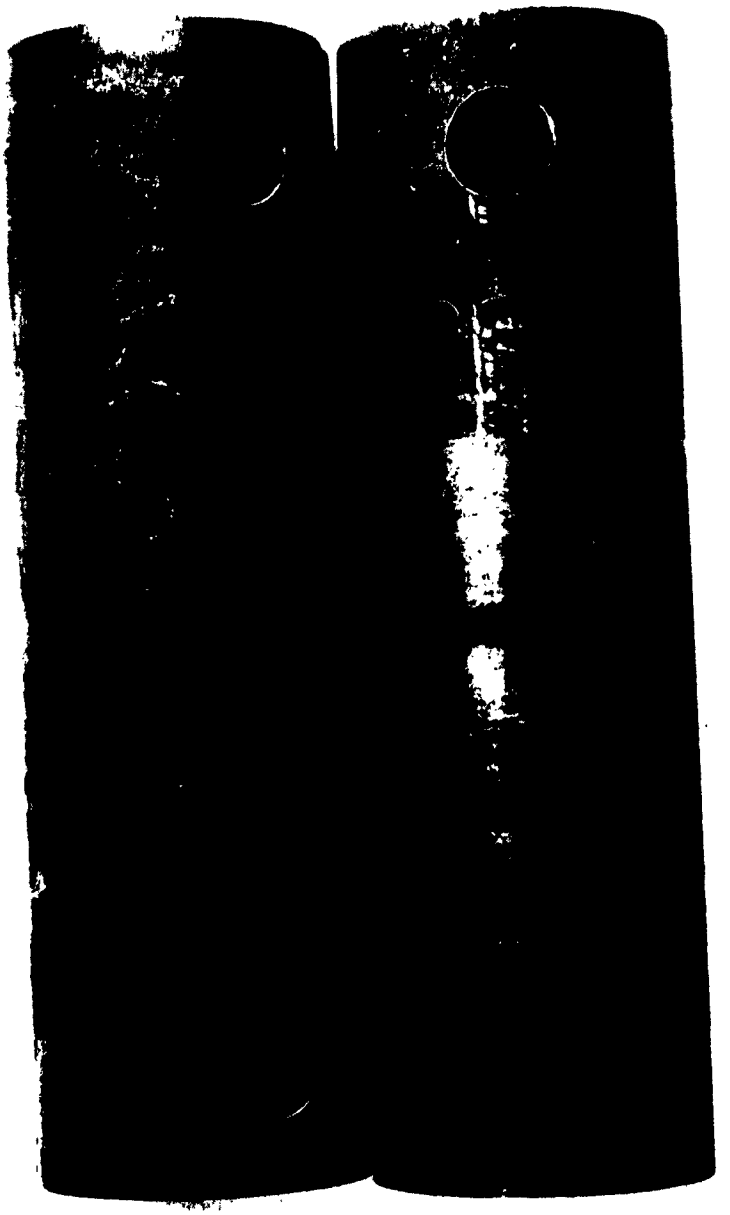


FIGURE 2.6
RENE' 41 PIVOT END

FIGURE 2.7
IMPACT TEST QUICK
RELEASE MECHANISM

24 1785
1 3-62

117

NO. DZ-80086
SEC 2 PAGE 2-19

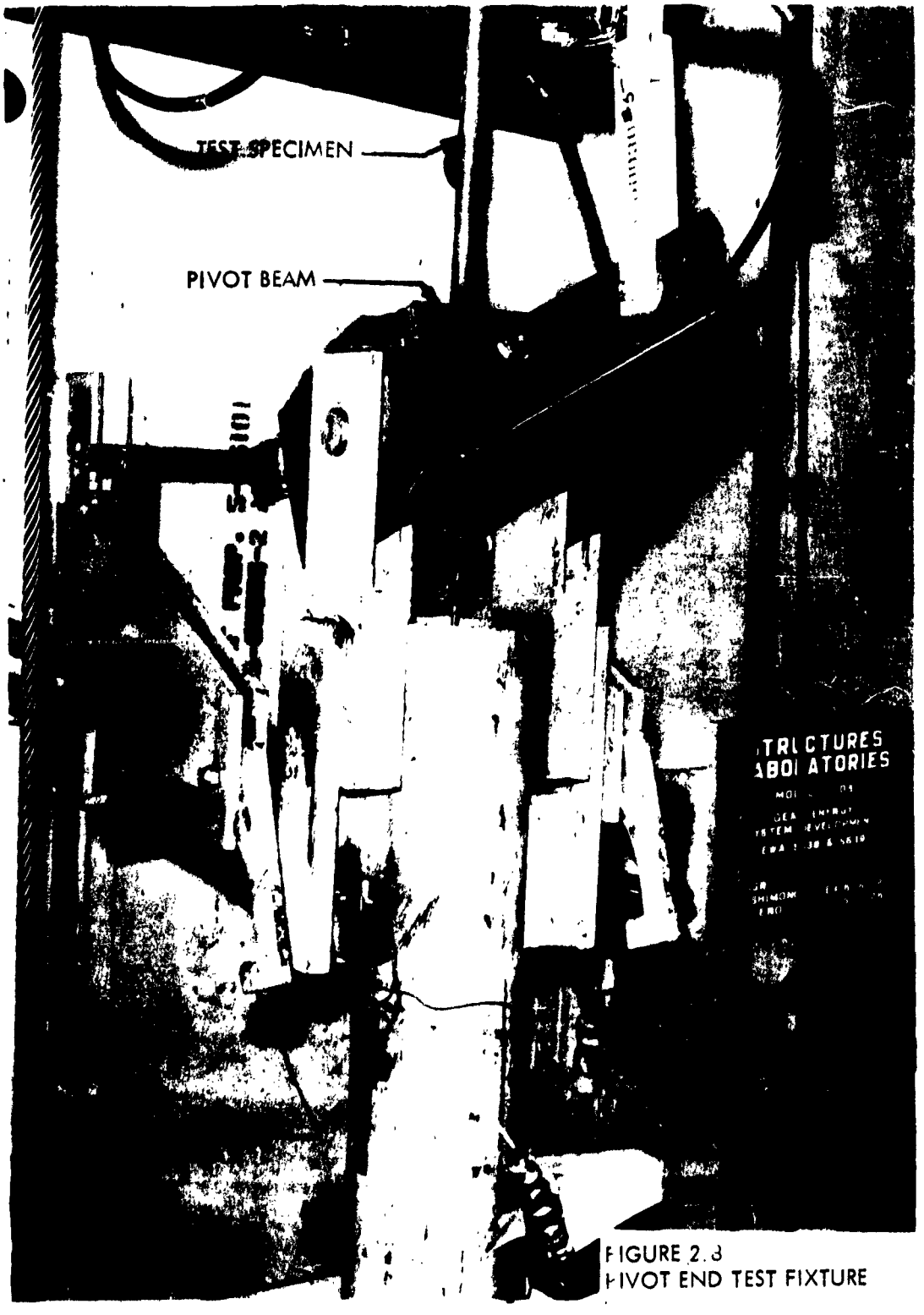


FIGURE 2.8
PIVOT END TEST FIXTURE

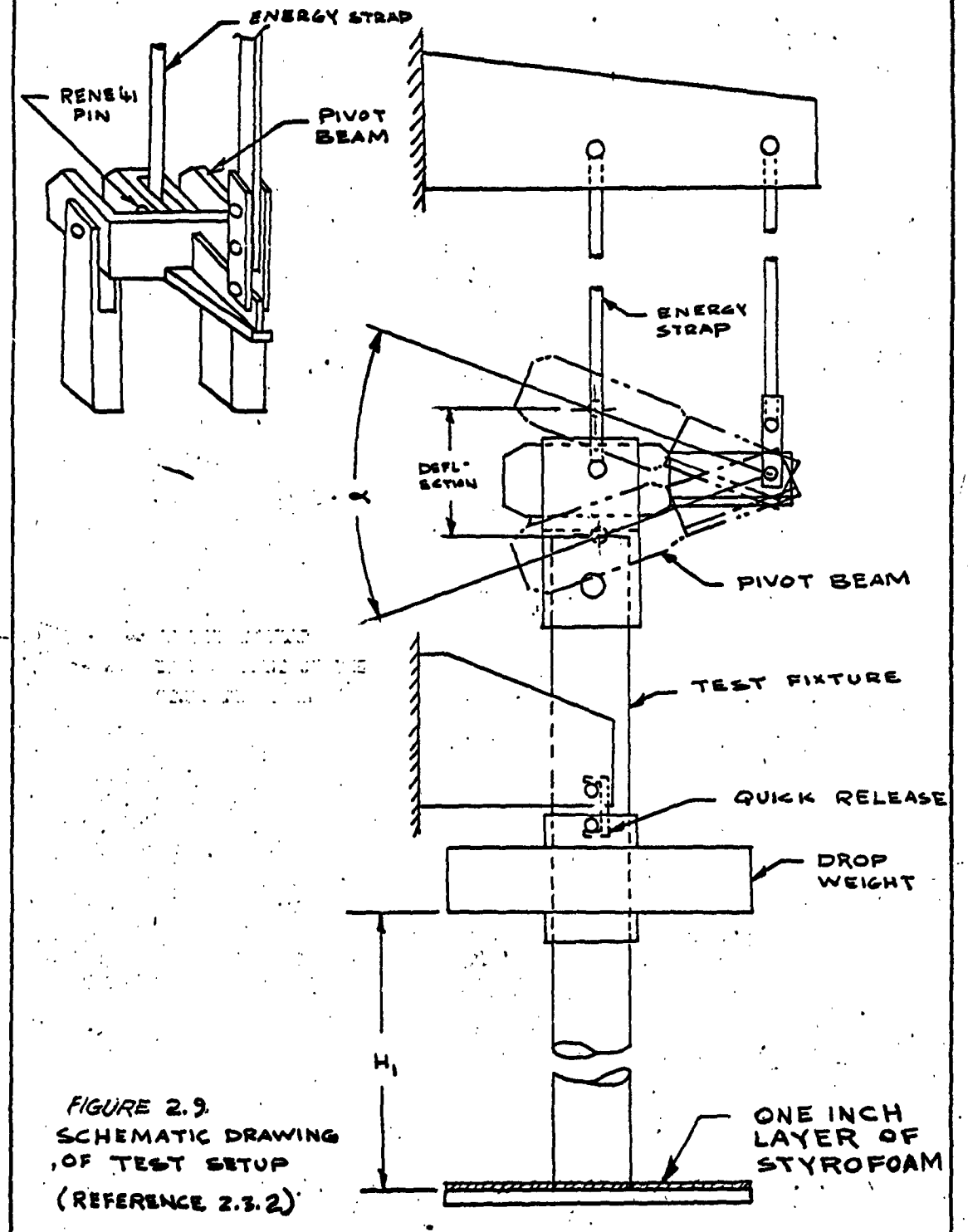


FIGURE 2.9
SCHEMATIC DRAWING OF TEST SETUP
(REFERENCE 2.3.2)

FIGURE 2.9

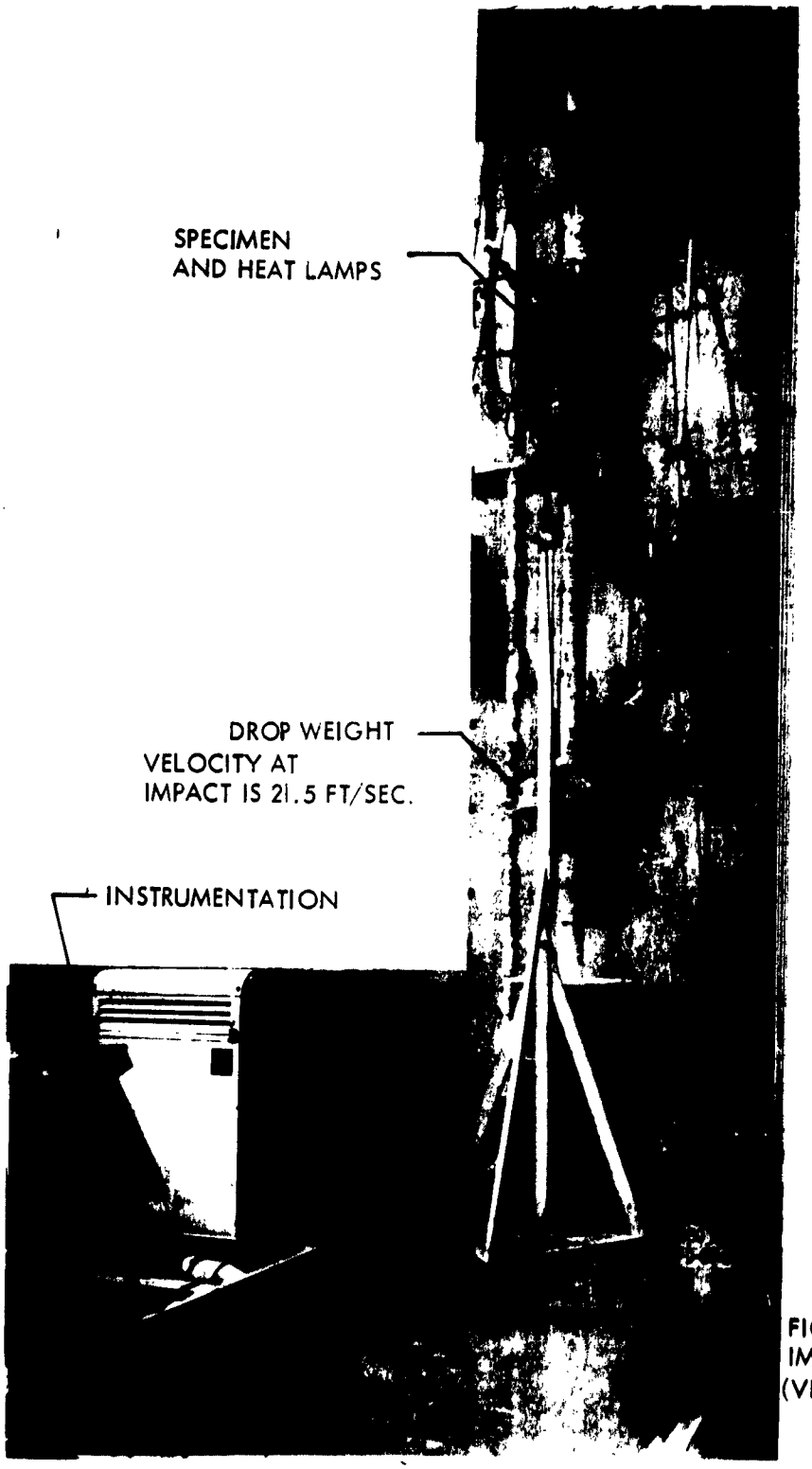


FIGURE 2.10
IMPACT TEST SETUP
(VELOCITY AT IMPACT
IS 21.5 FT/SEC)

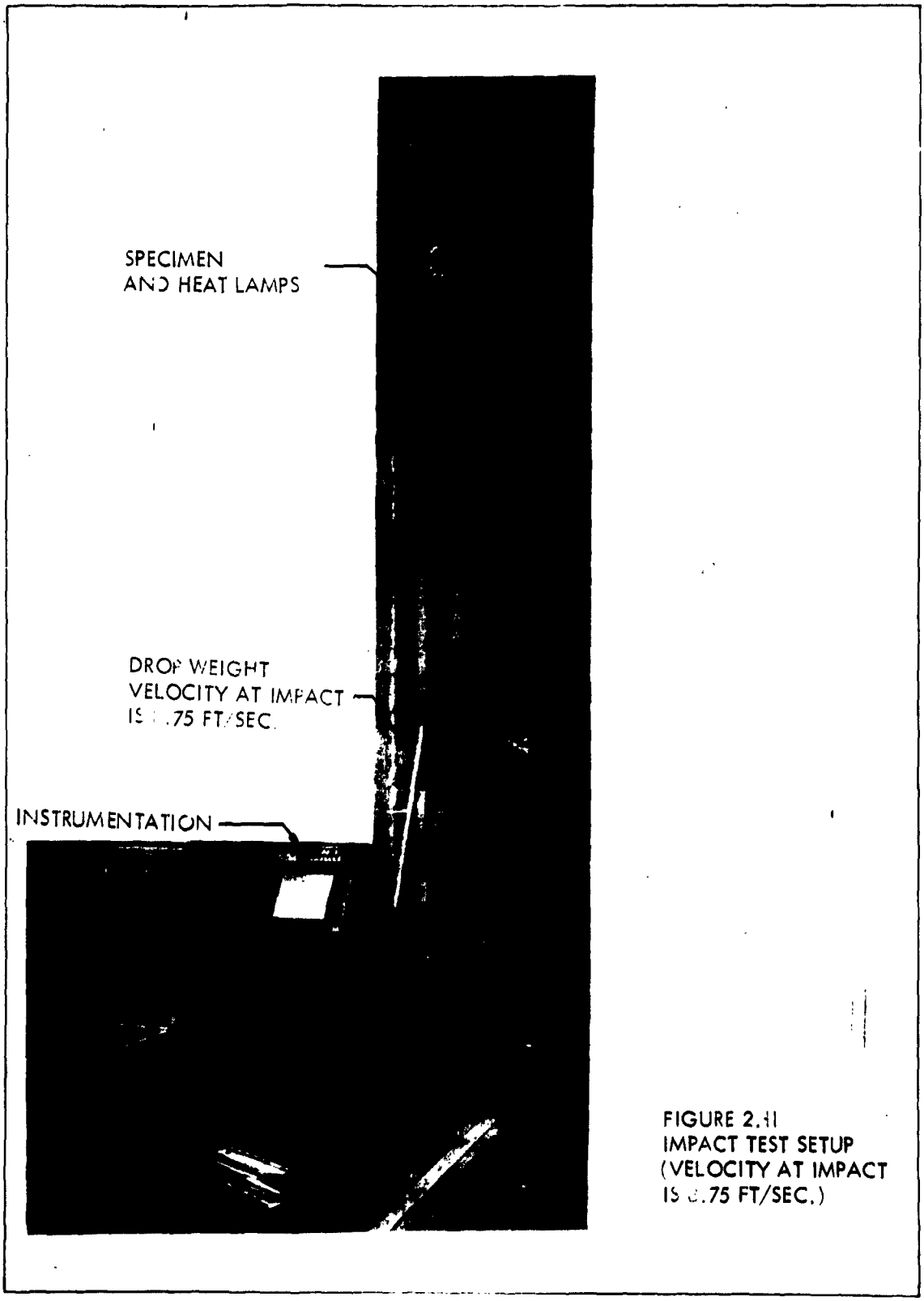
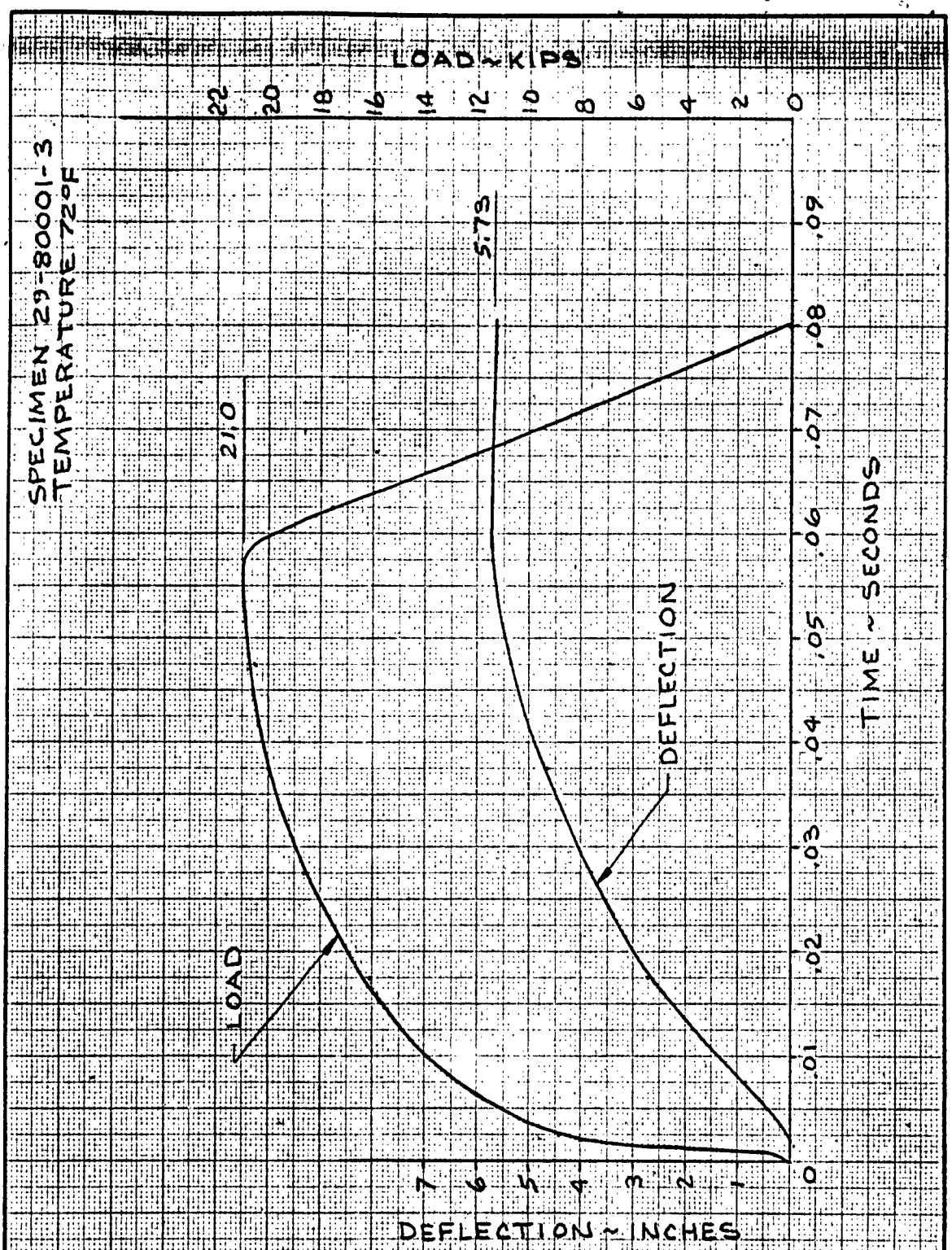


FIGURE 2.11
IMPACT TEST SETUP
(VELOCITY AT IMPACT
IS 2.75 FT/SEC.)



CALC	L. Krebo	12-26-1	REVISED	DATE
CHECK				
APR				
APR				

LOAD & DEFLECTION Vs TIME SPECIMEN No. 1

X-20

D2-80086

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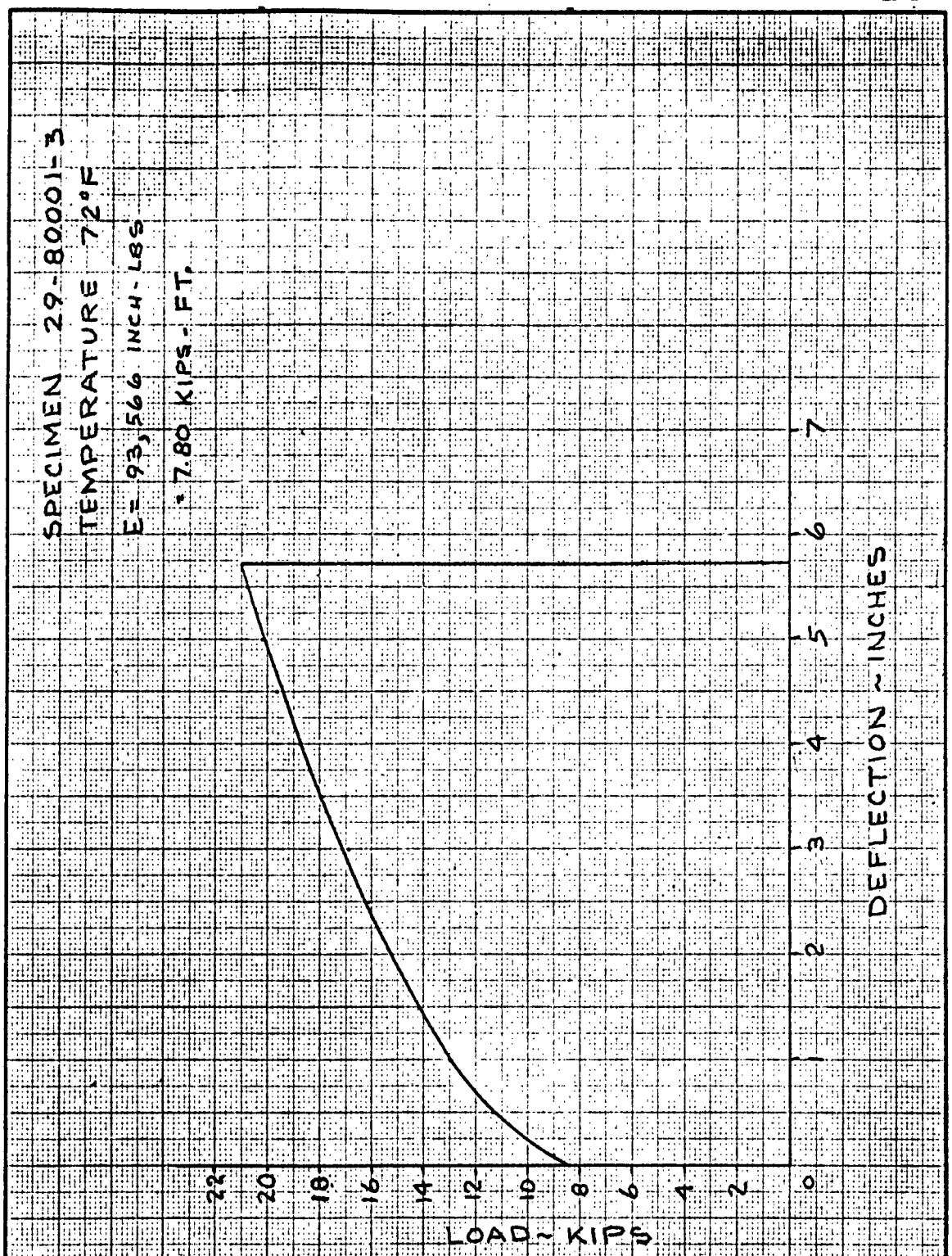
U3 4013 8000

60629



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CHECK				
APR				
APR				

LOAD vs DEFLECTION
SPECIMEN No. 1

X-20

D2-80086

THE BOEING COMPANY

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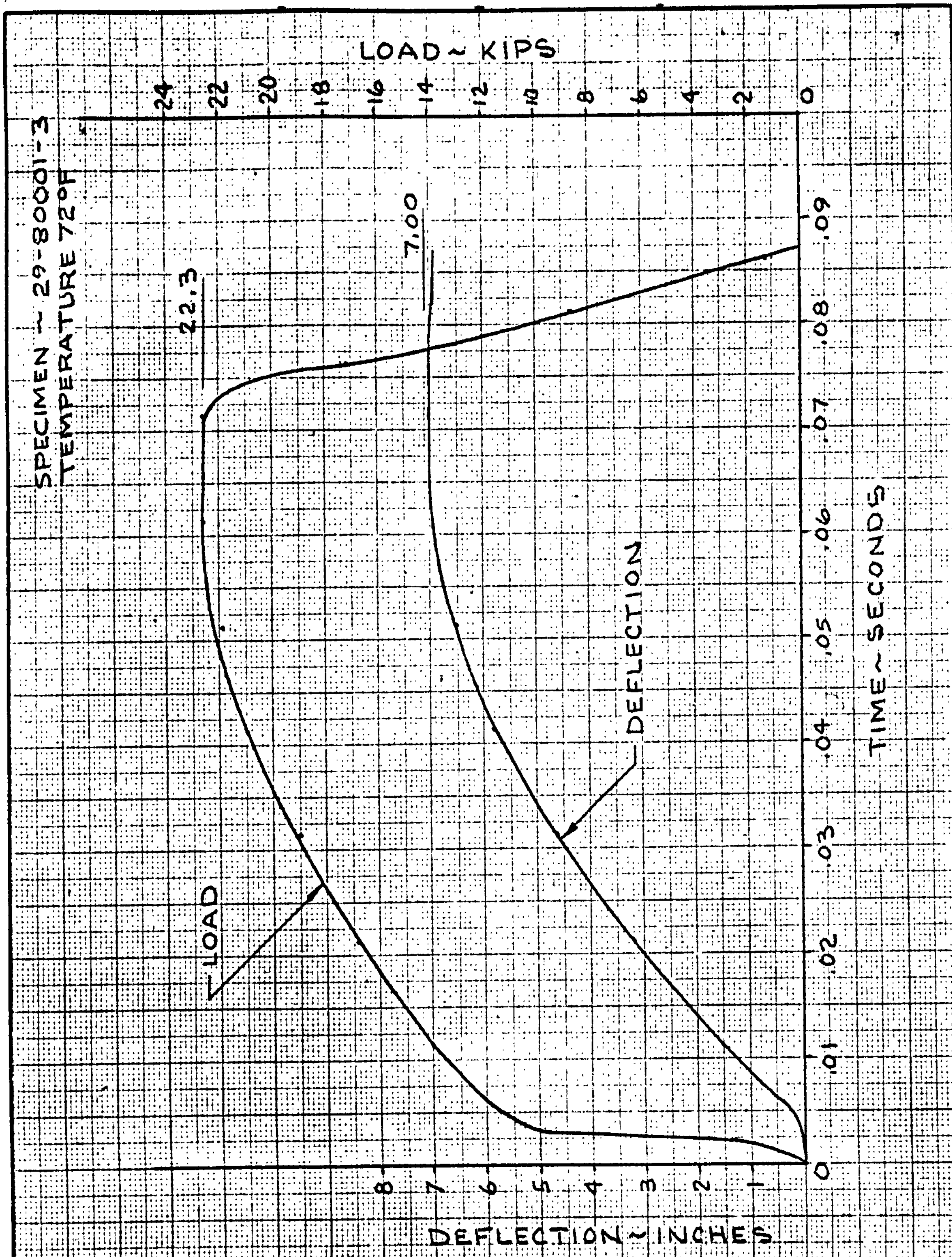
M-E ALBANENE TOOL 60629



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CHECK						D2-80086
APR					THE BOEING COMPANY	PAGE 2-27
APR						

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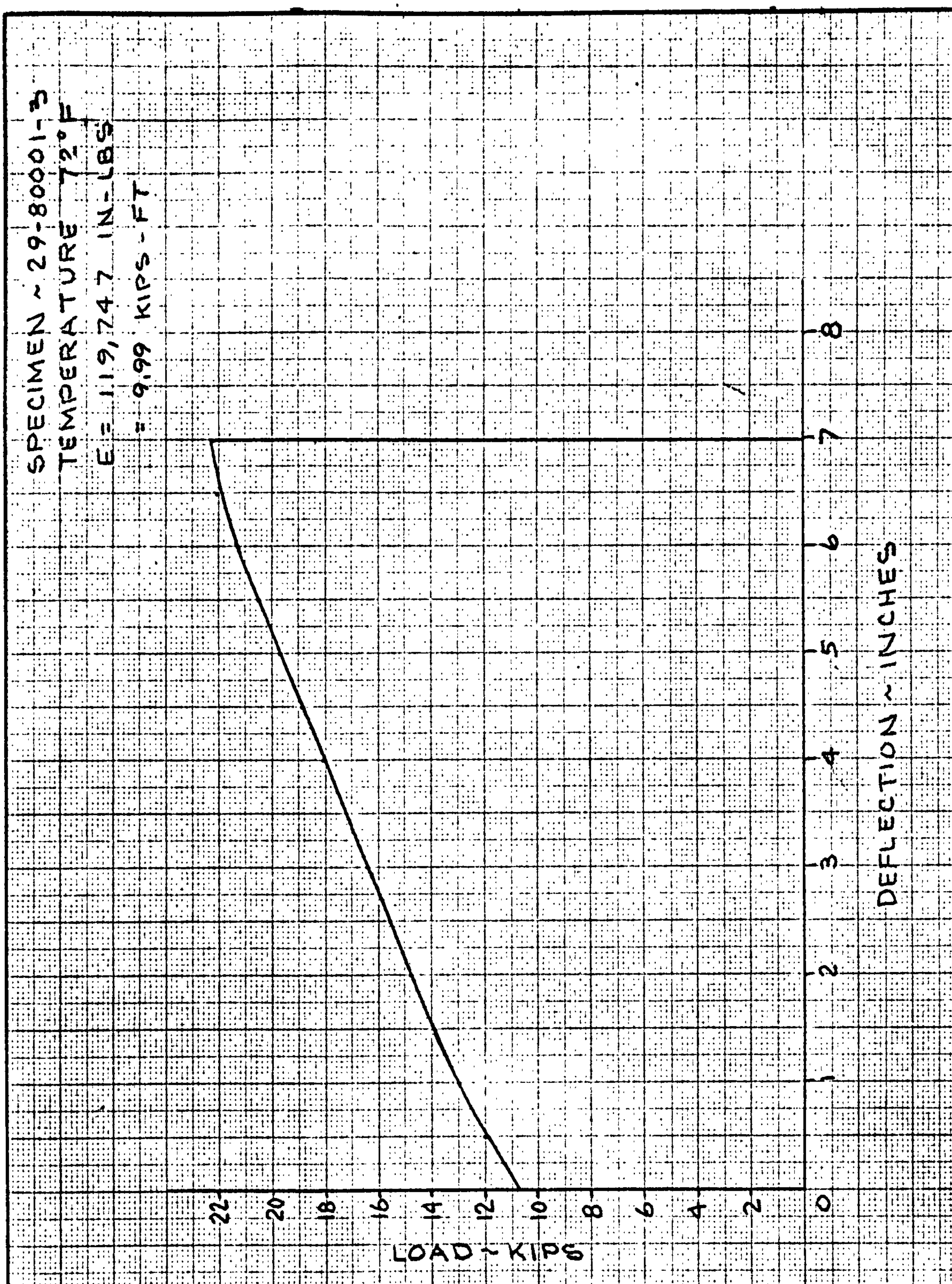

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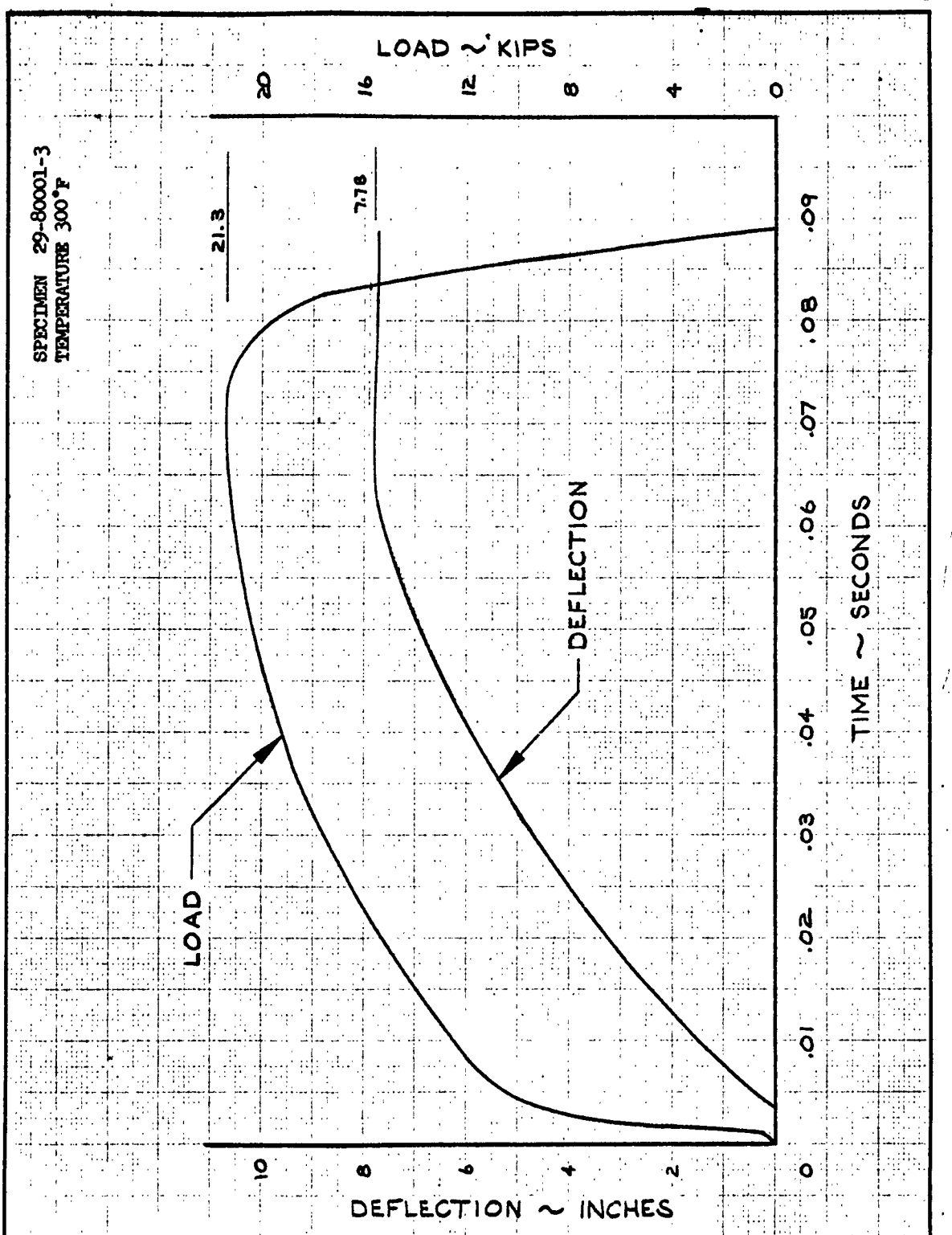
CHECK						D2-80086
APR					THE BOEING COMPANY	PAGE 2-28
APR						



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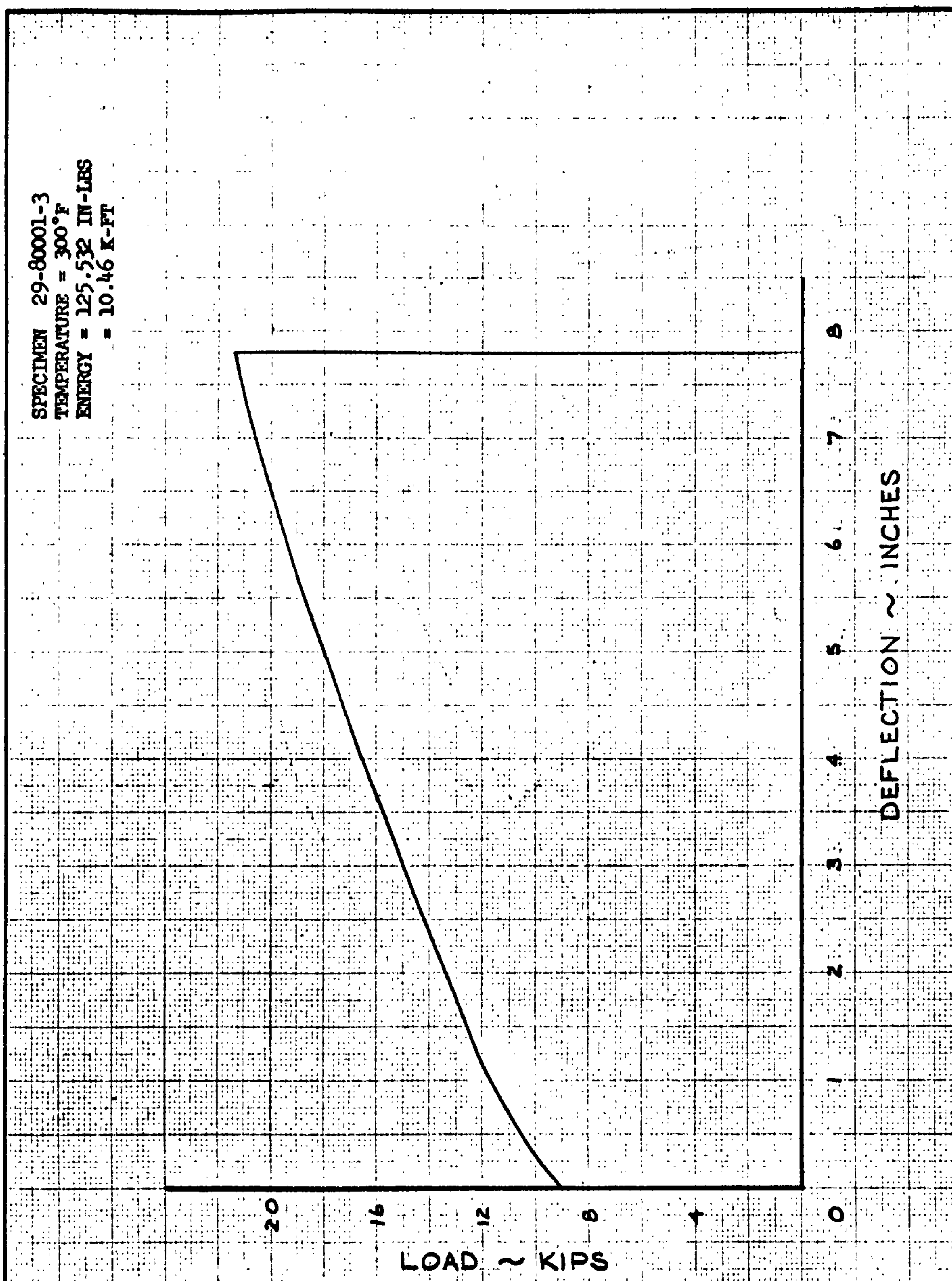
APR						
APR					THE BOEING COMPANY	PAGE 2-29



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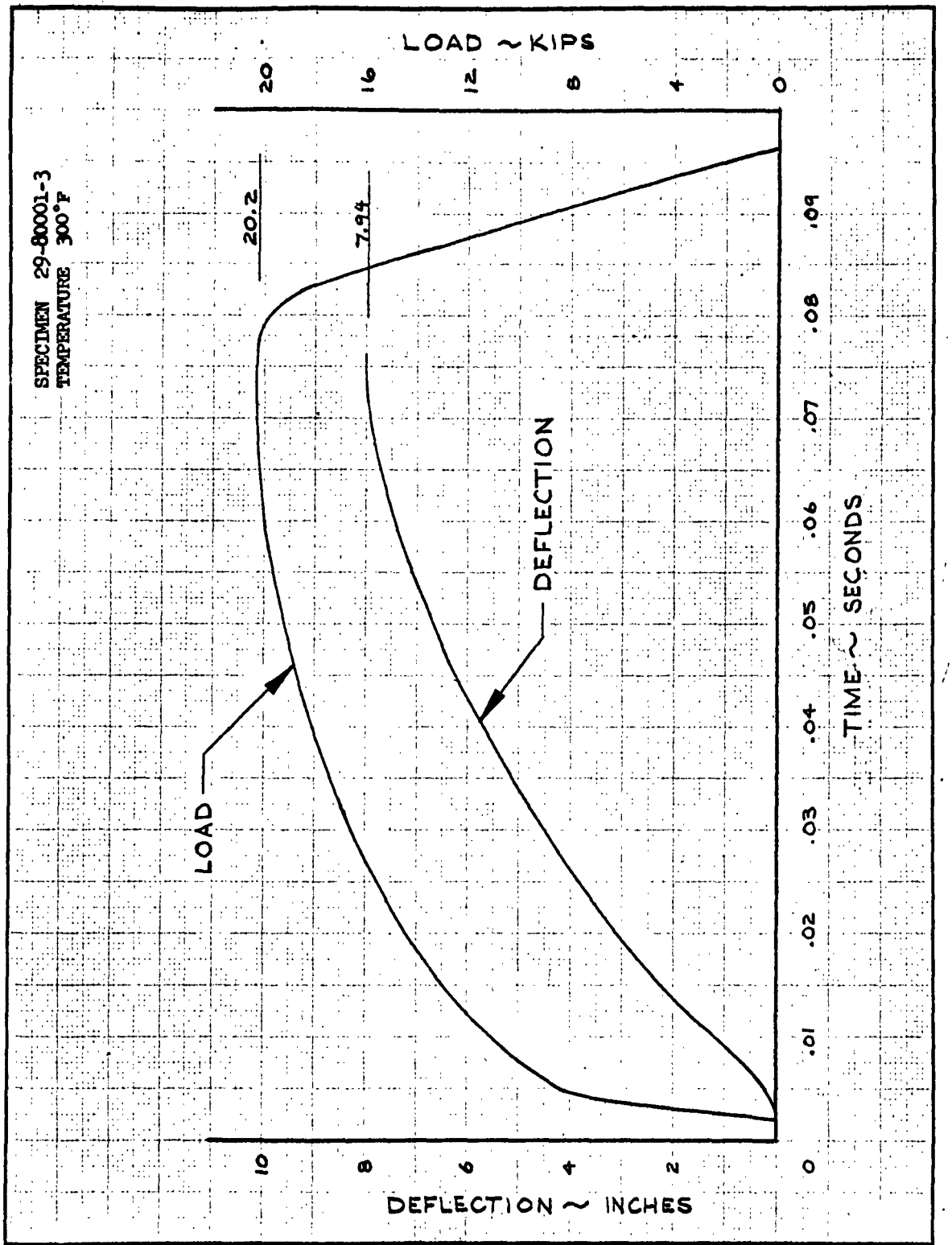
CHECK						D2-80086
APR					THE BOEING COMPANY	PAGE 2-30
APR						



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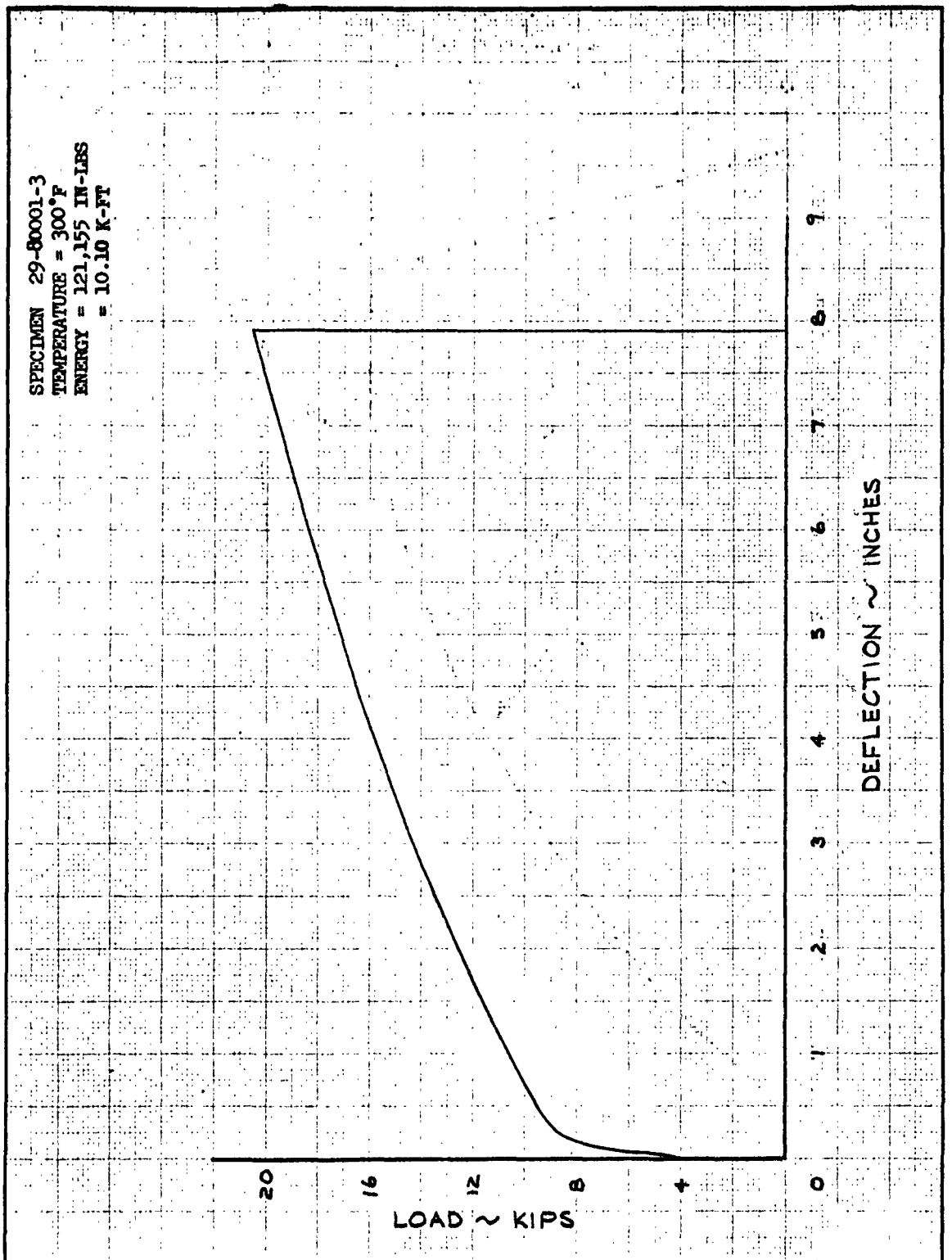
CHECK						D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 2-31



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CHECK					
APR					
APR					
					THE BOEING COMPANY

X-20

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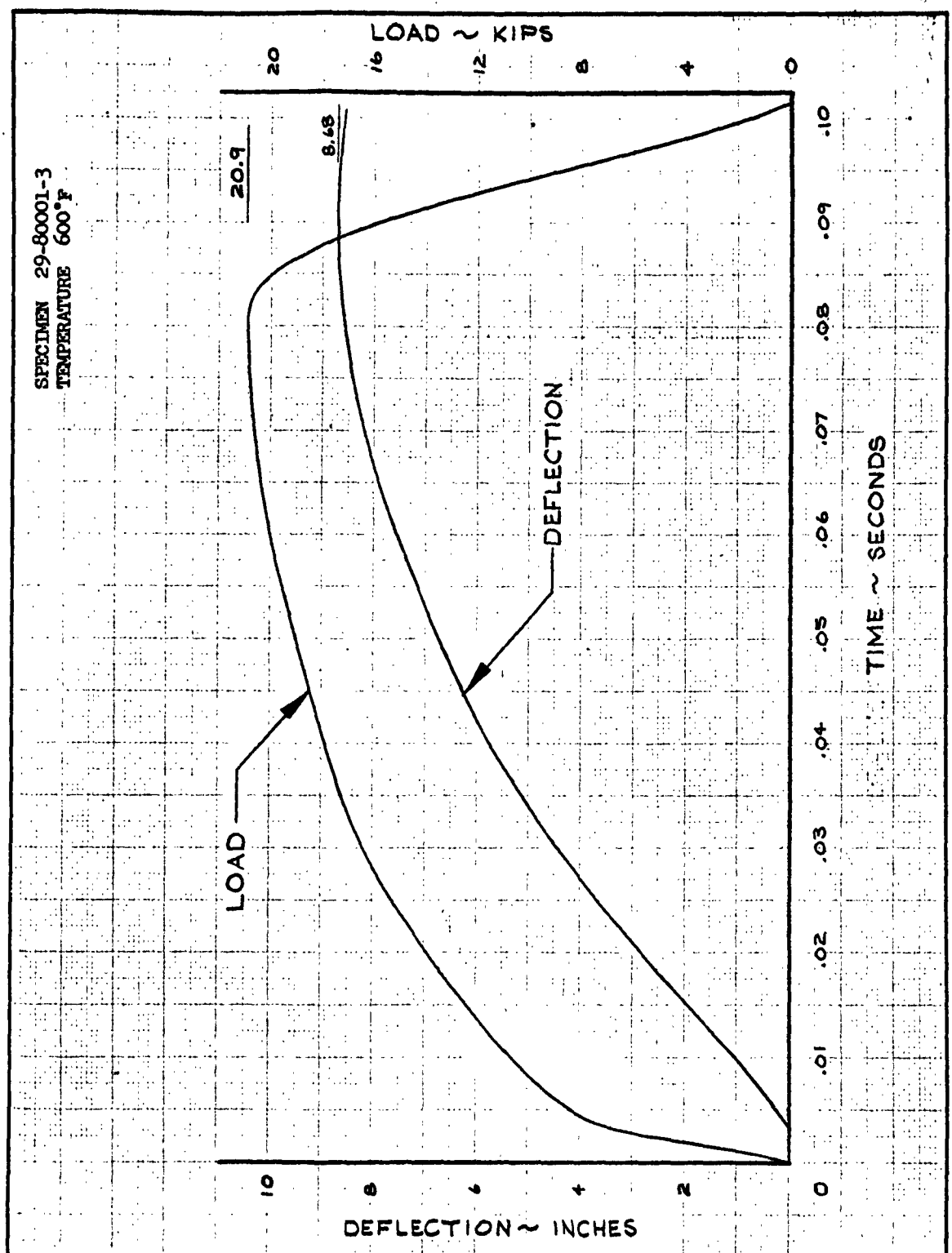

CALC	J.Lebo	12-19-1	REVISED	DATE
CHECK				
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APR				

LOAD & DEFLECTION VS TIME SPECIMEN NO. 6

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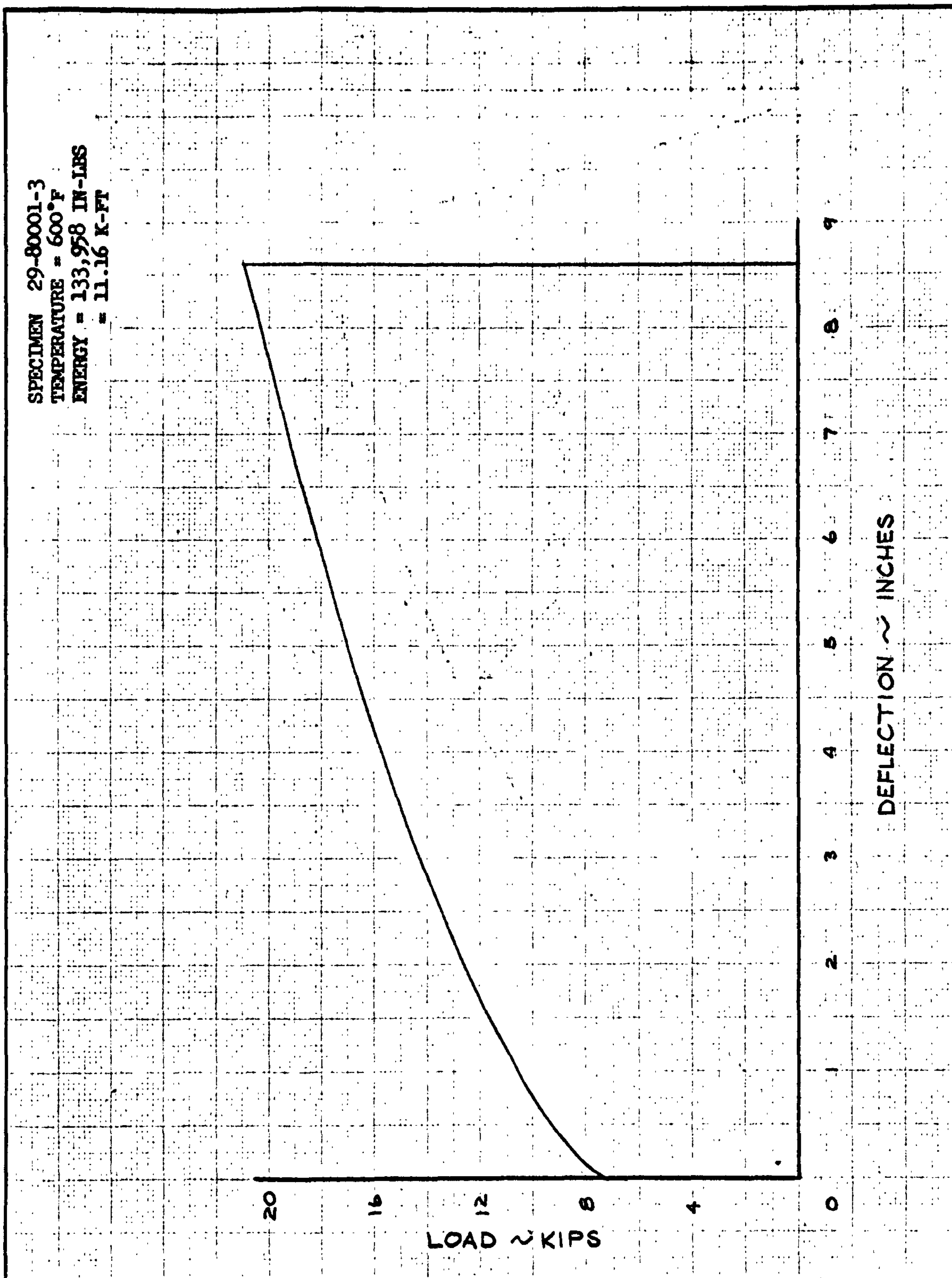

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CHECK					
APR					THE BOEING COMPANY
APR					

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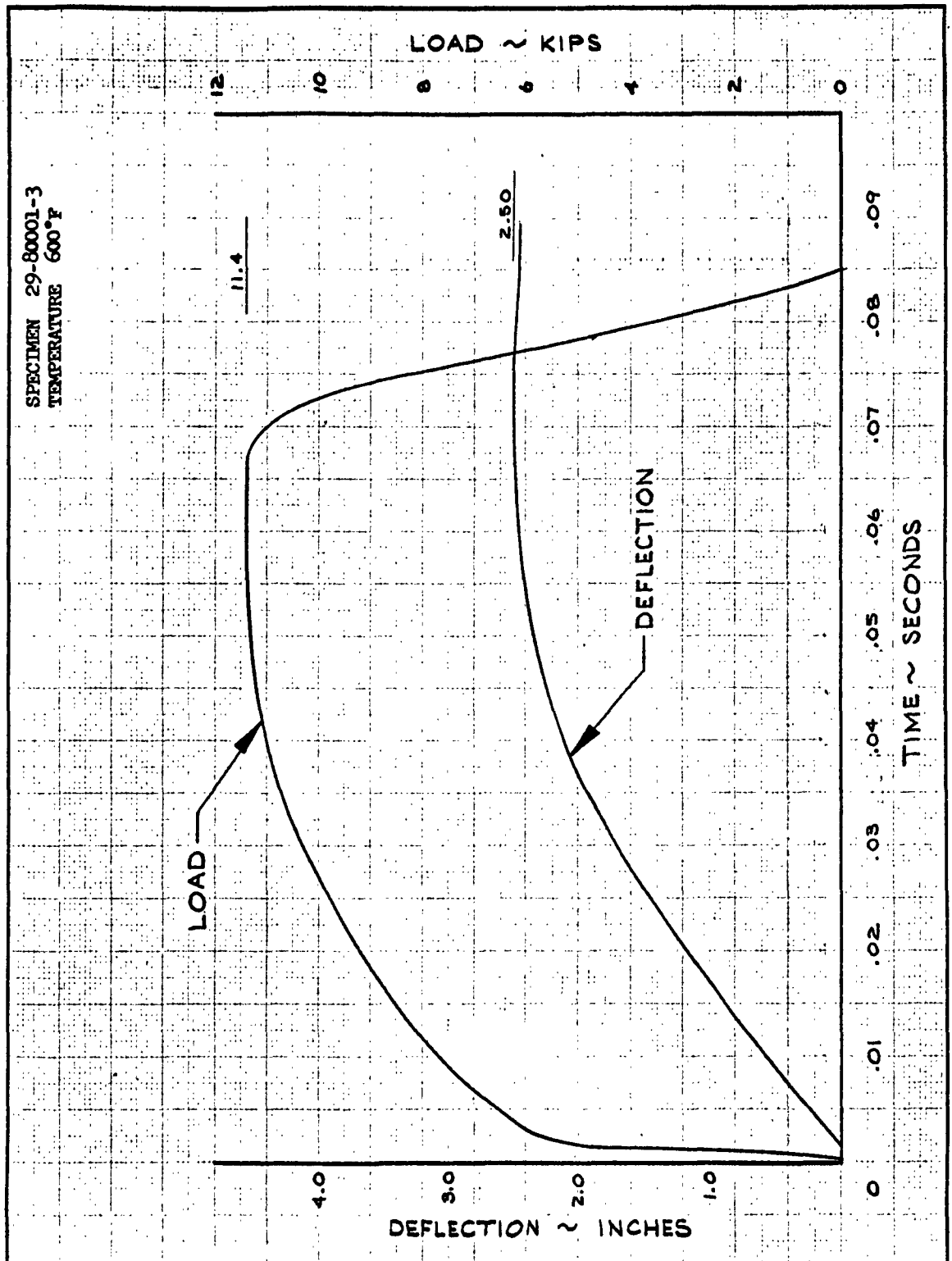

CALC	J.Lebo	2-27-2	REVISED	DATE
CHECK	Jorgensen	2-28-2		
APR				
APR				

LOAD & DEFLECTION VS TIME
SPECIMEN NO. 19

X-20

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US 4018 8000

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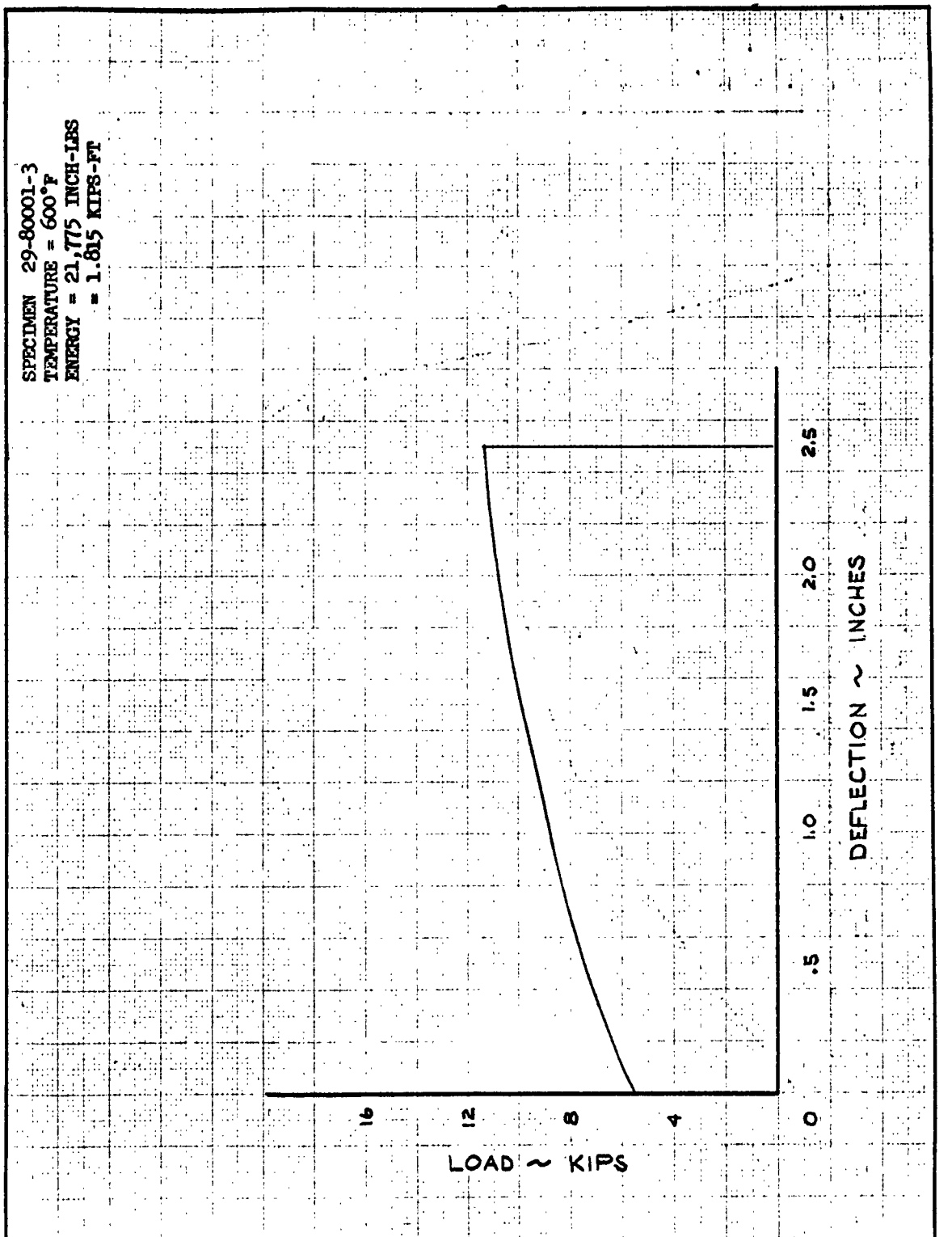

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CHECK	Jorgensen	2-28-			
APR					
APR					
					THE BOEING COMPANY

X-20

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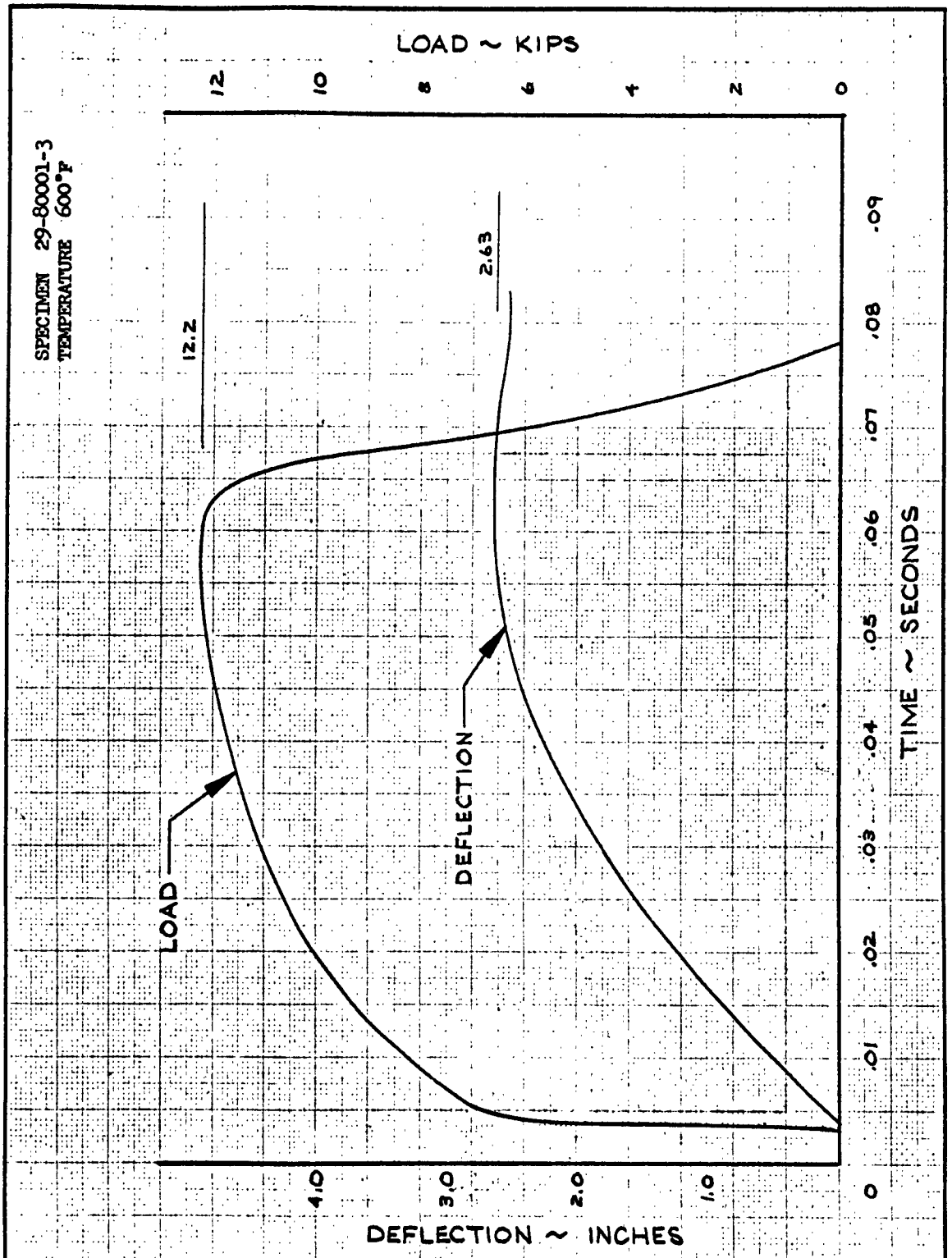

CALC	J.Lebo	2-27-[illegible]	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 20	X-20
CHECK	Jorgensen	2-28-[illegible]				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 2-57

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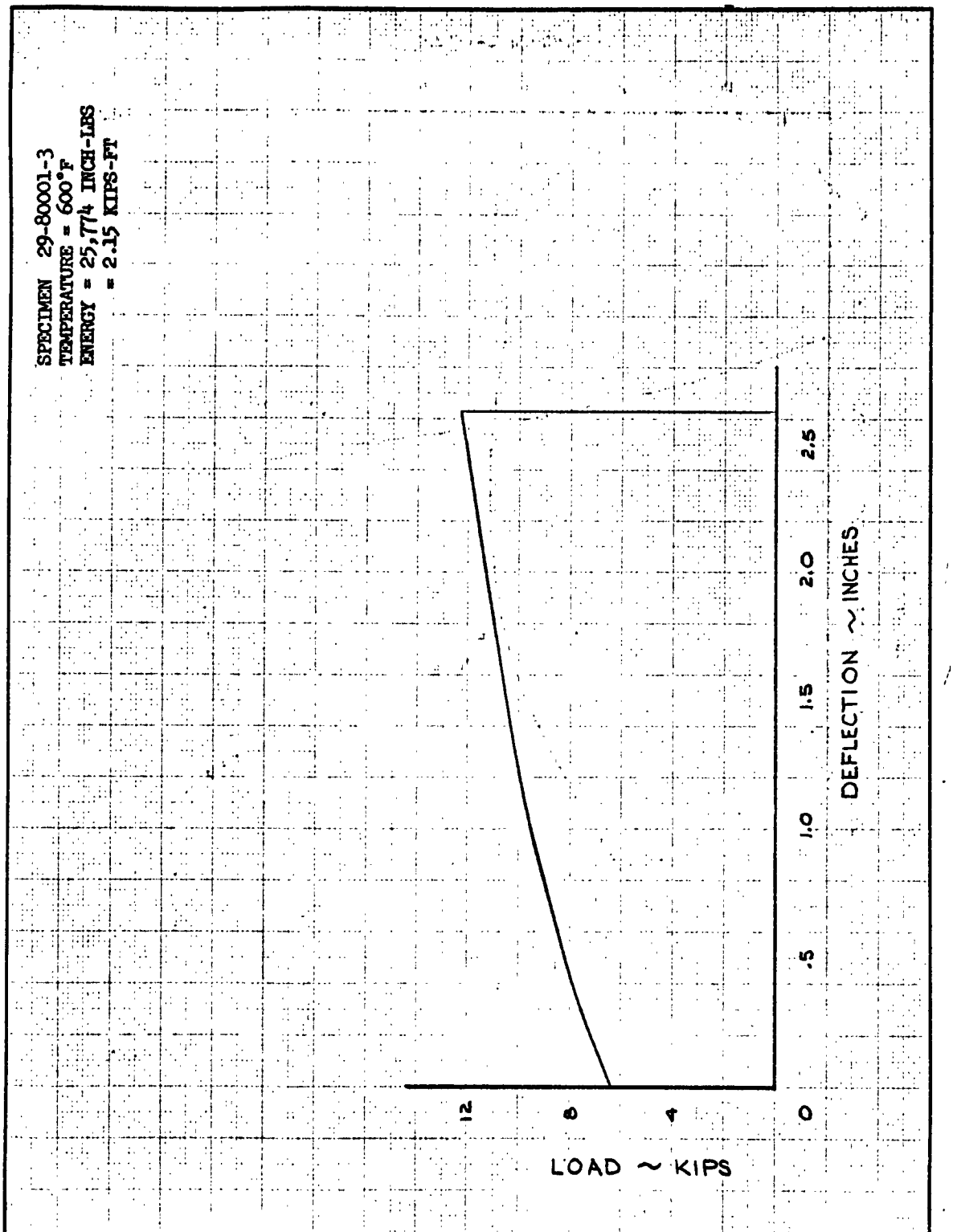
K•E ALBANENE® TRACING PAPER 70317

134

SPECIMEN 29-80001-3
TEMPERATURE = 600°F
ENERGY = 25,774 INCH-LBS
= 2.15 KIPS-FT



CALC	J.Lebo	2-27-	REVISED	DATE
CHECK	Jorgensen	2-28-		
APR				
APR				

LOAD VS DEFLECTION
SPECIMEN NO. 20

X-20

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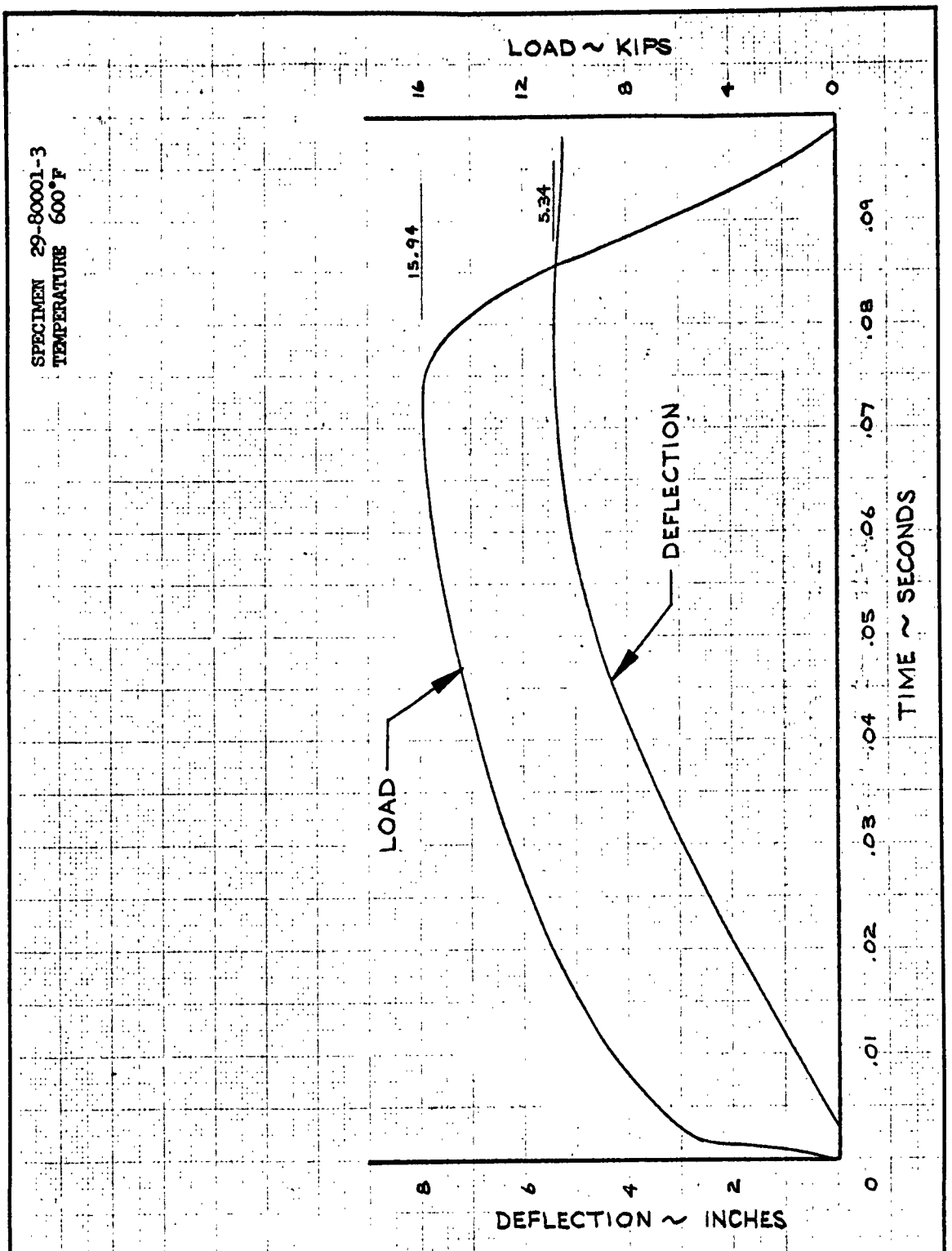

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CHECK	Jorgensen	8-7-2			
APR					
APR					THE BOEING COMPANY

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K•E ALBANENE® TRACING PAPER 70317

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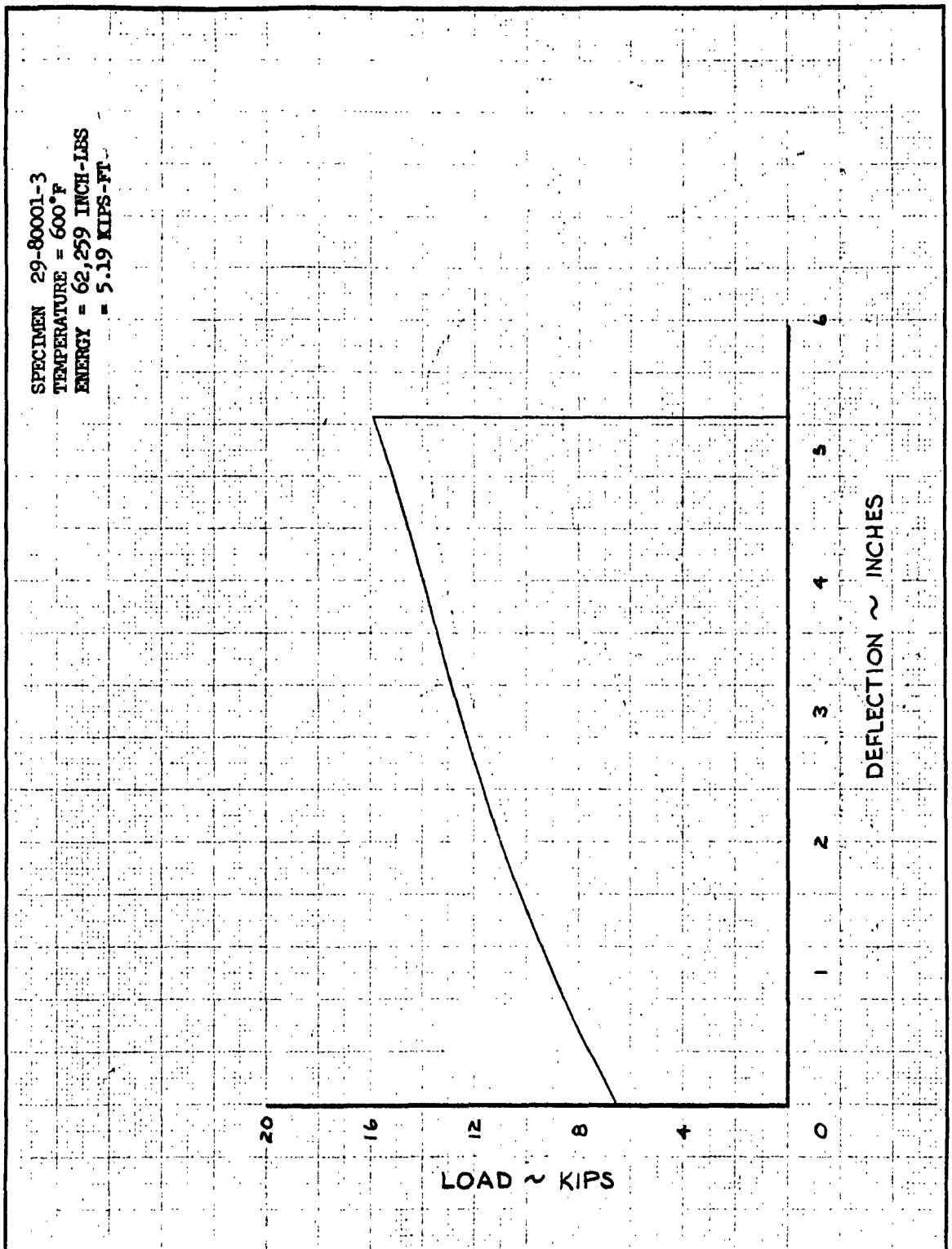
SPECIMEN 29-80001-3
TEMPERATURE = 600°F
ENERGY = 62,259 INCH-LBS
= 5.19 KIPS-FT



CALC	J.Lebo	3-1-2	REVISED	DATE
CHECK	Jorgensen	3-7-2		
APR				
APR				

LOAD VS DEFLECTION
SPECIMEN NO. 21

X-20

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THE BOEING COMPANY

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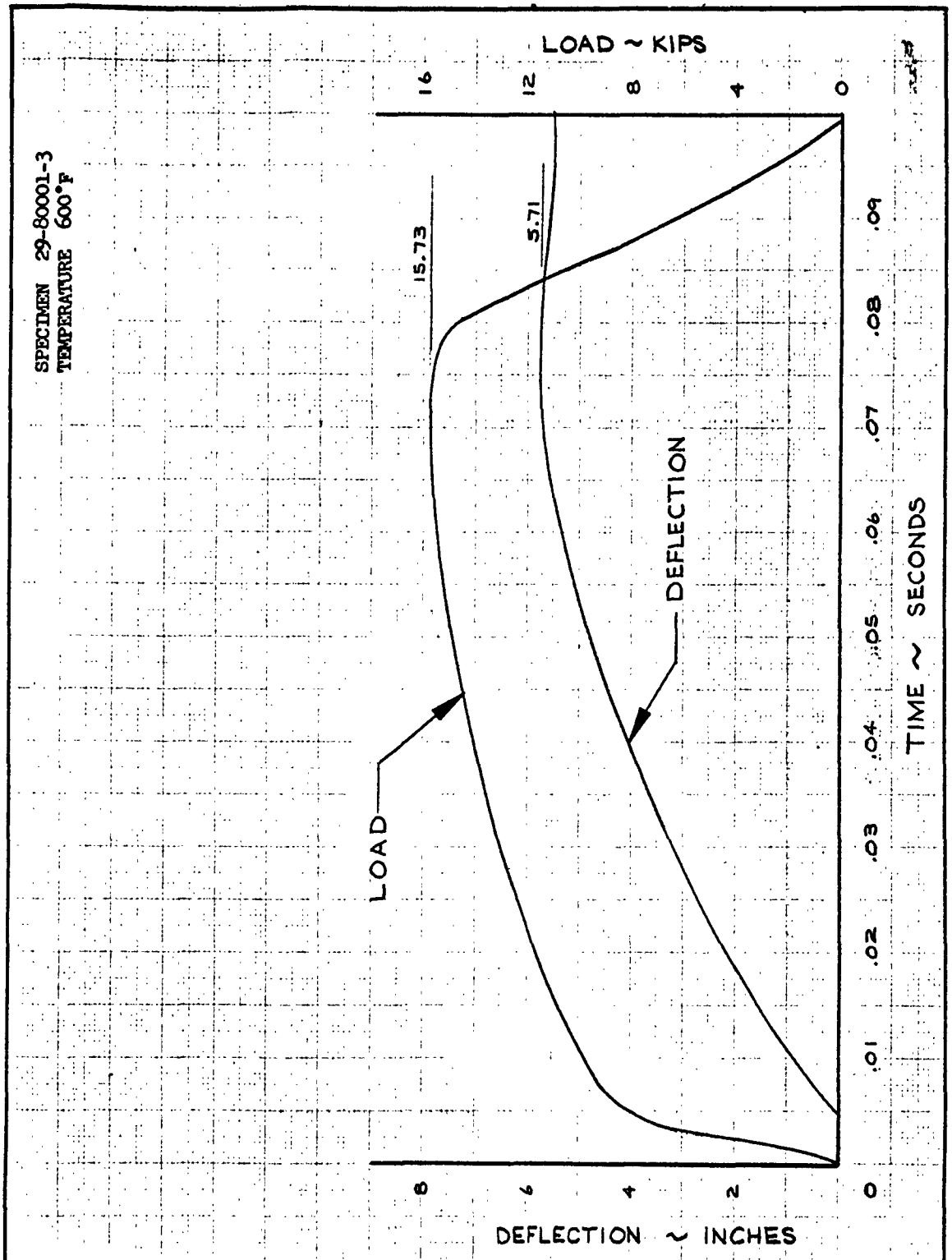

CALC	J.Lebo	3-2-2	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 22
CHECK	Jorgensen	3-7-2			
APR					
APR					
					THE BOEING COMPANY

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PAGE 2-41

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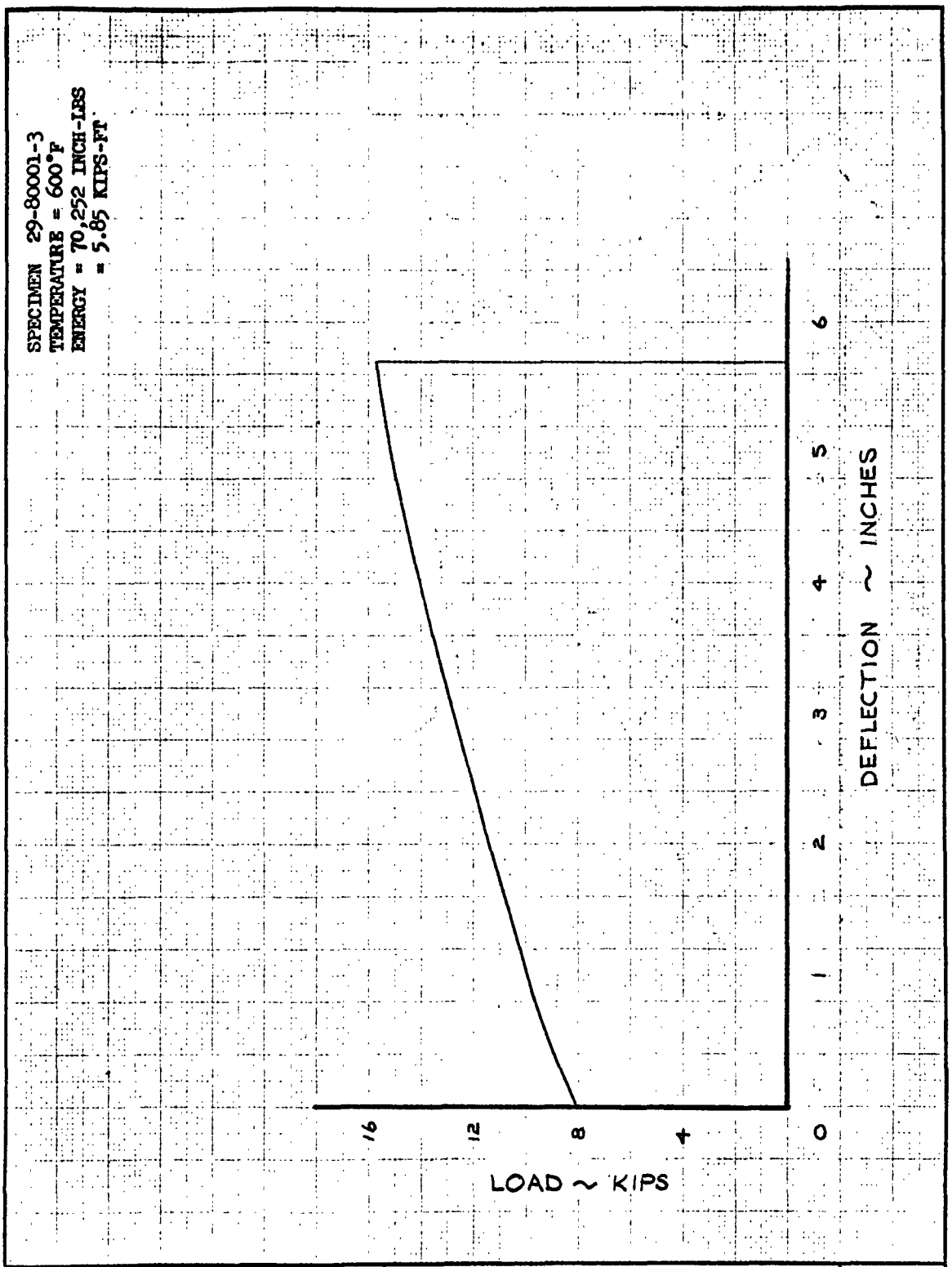
K•E ALBANENE® TRACING PAPER 70317



CALC	J.Lebo	3-2-2	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 22
CHECK	Jorgensen	3-7-2			
APR					
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					THE BOEING COMPANY

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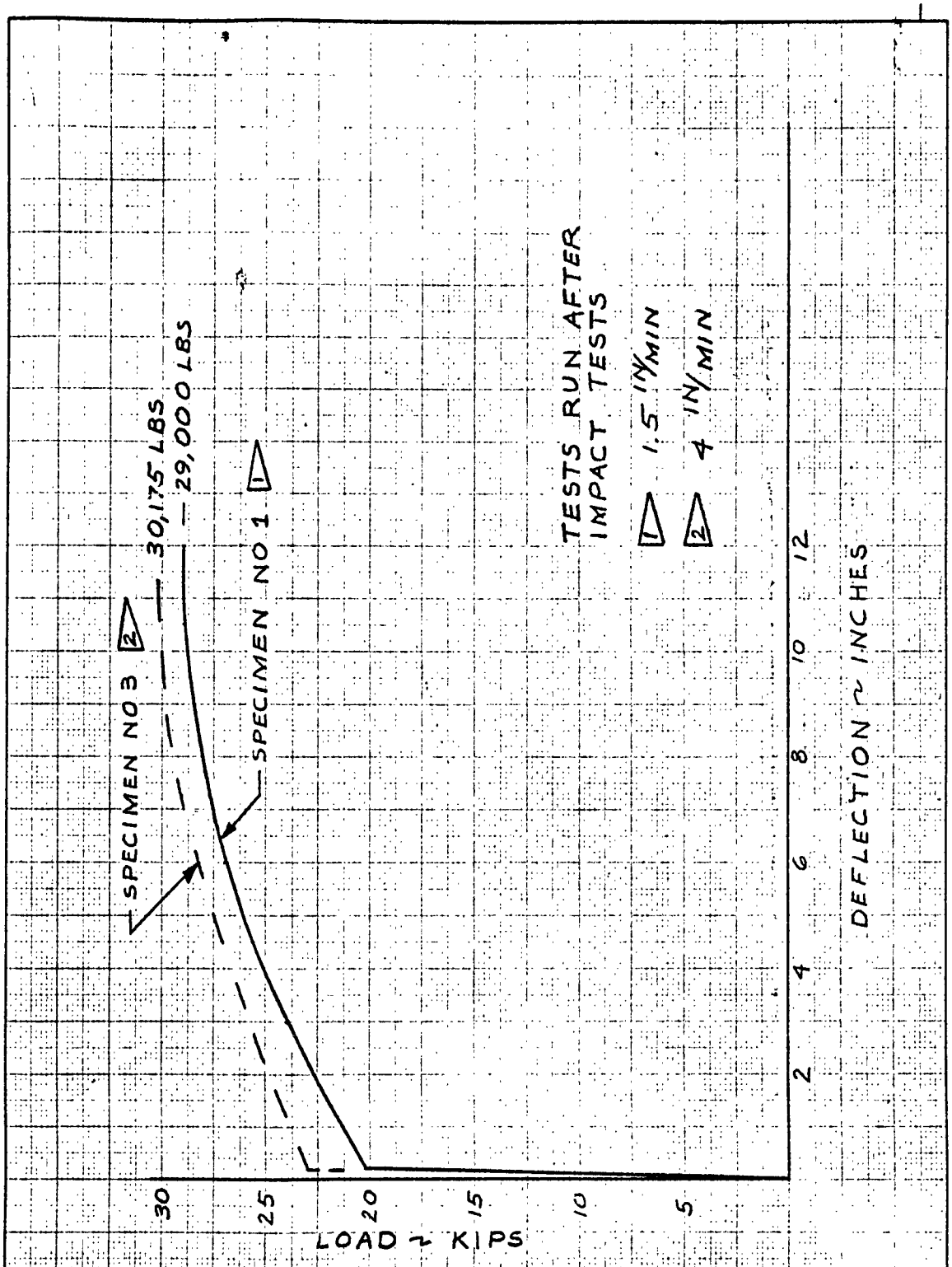

CALC	P.J. MOORE	11-27-71	REVISED	DATE	LOAD VS DEFLECTION SPECIMENS 1 & 3
CHECK					
APR					
APR					
					BOEING AIRPLANE COMPANY

X-20
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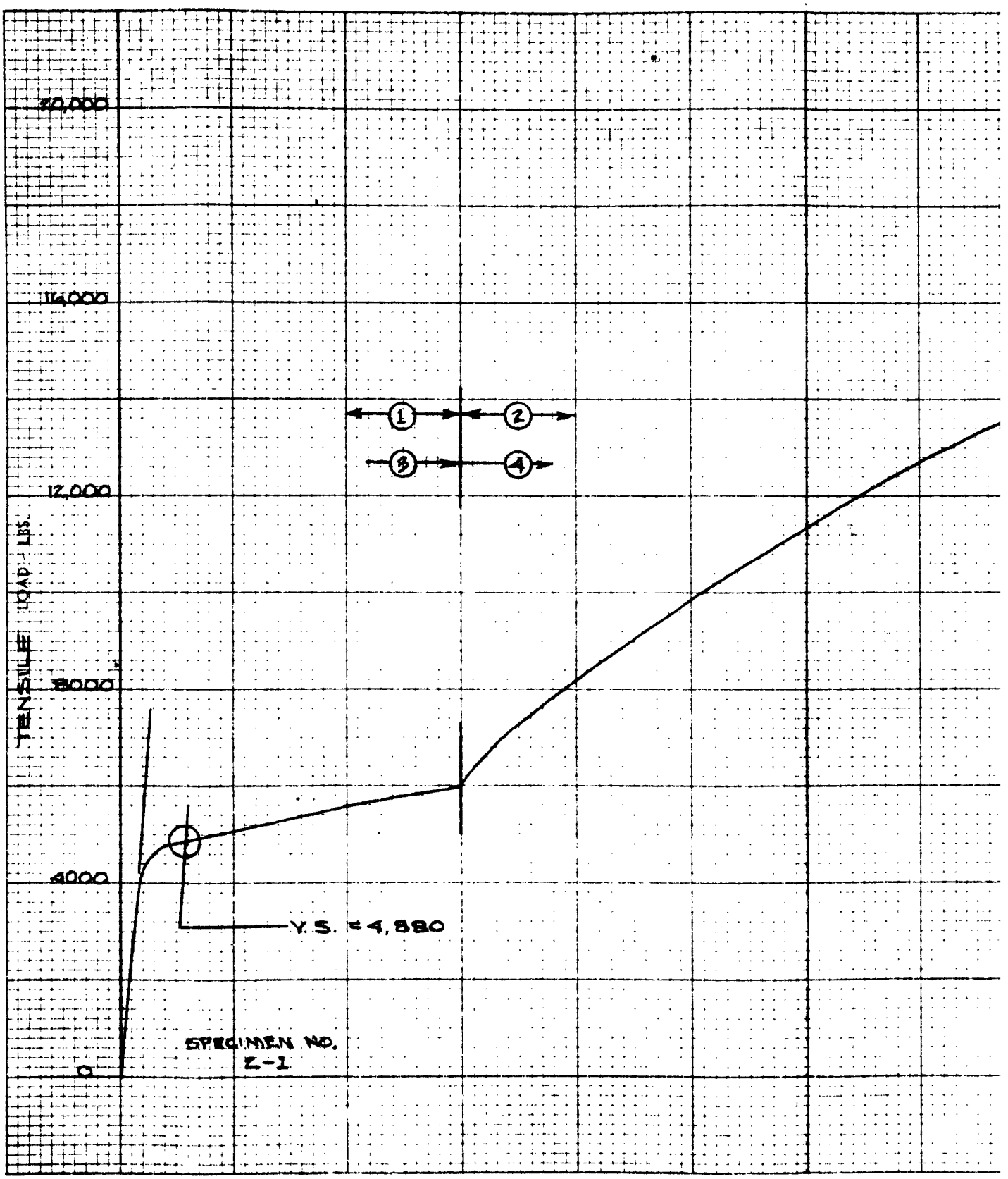
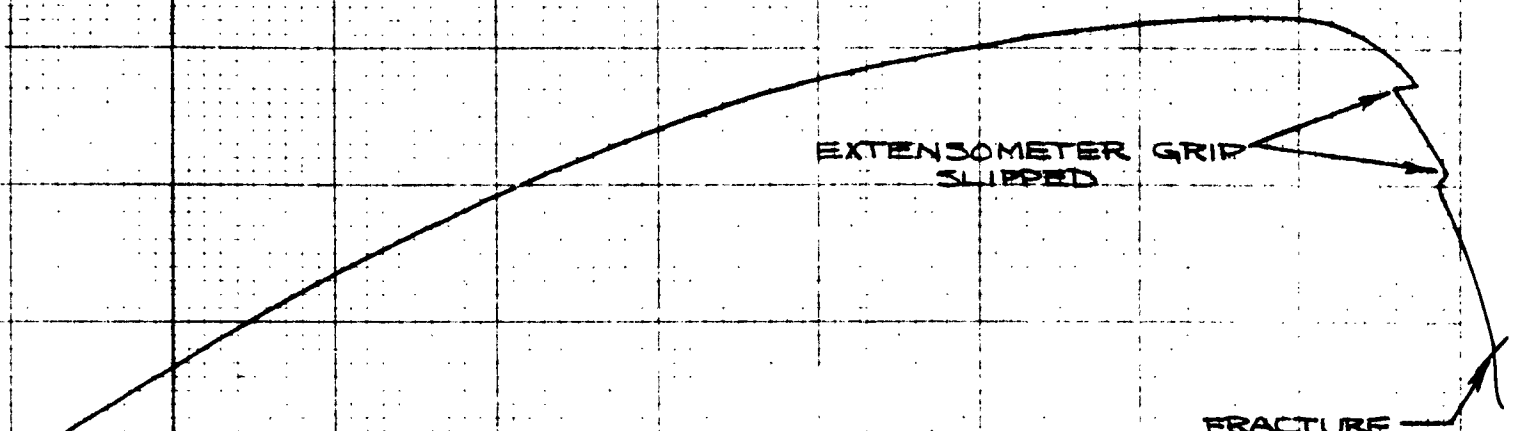
BAC 461 C-R4

60629



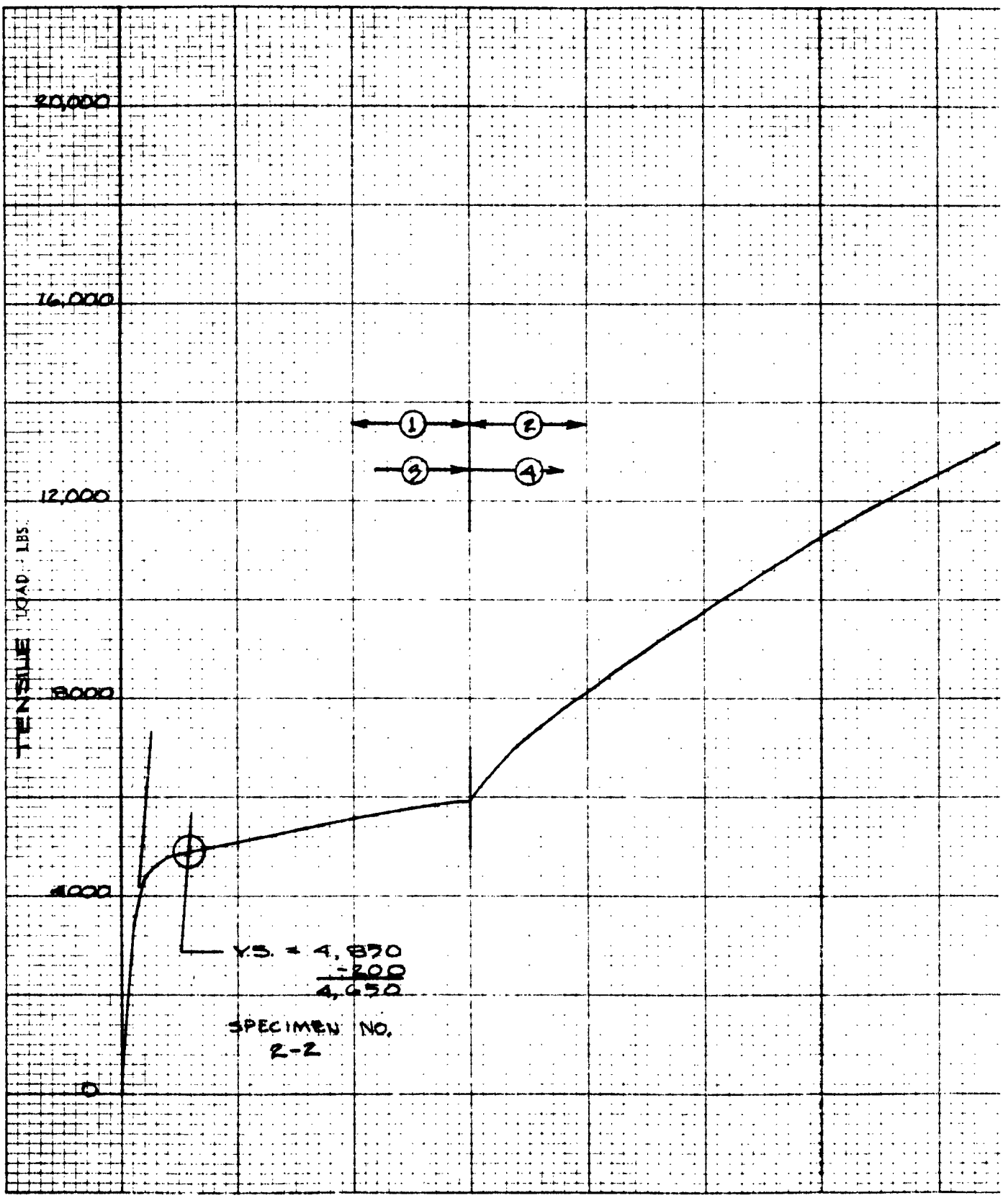
For 120K machine only



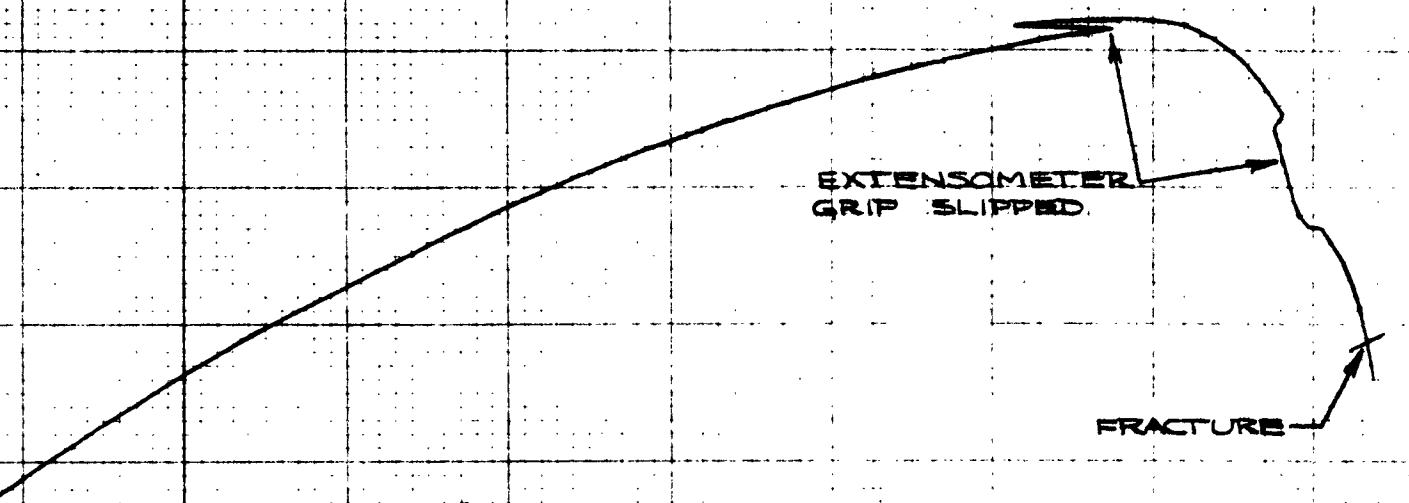
2

	STRAIN IN/IN	STRAIN RATE IN/IN/MIN	LOAD RATE	DEFLECTION
	① .005	③ .005		
	② .050	④ 0.10		

ELS 4/20/3



For 120K machine only

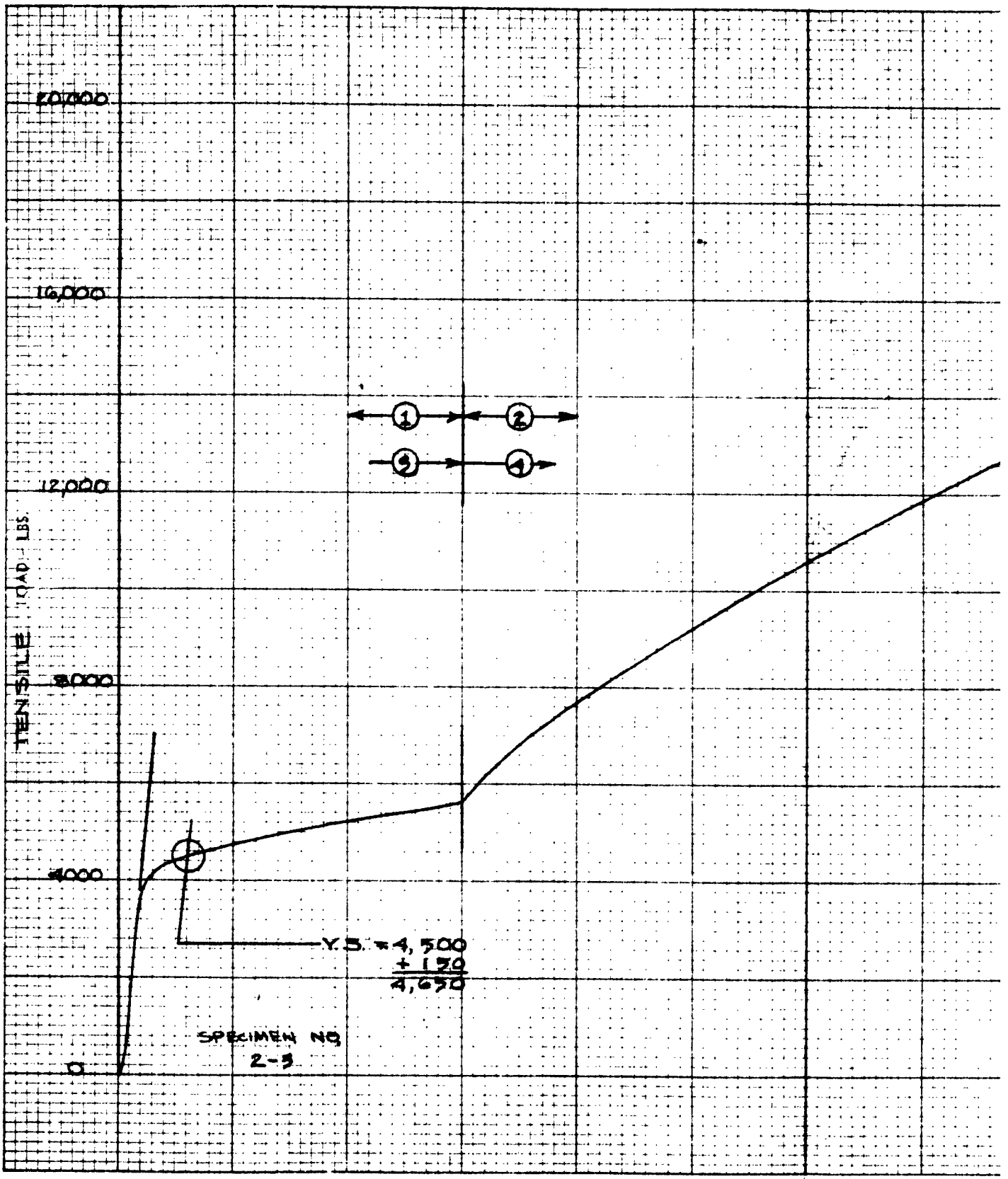


2

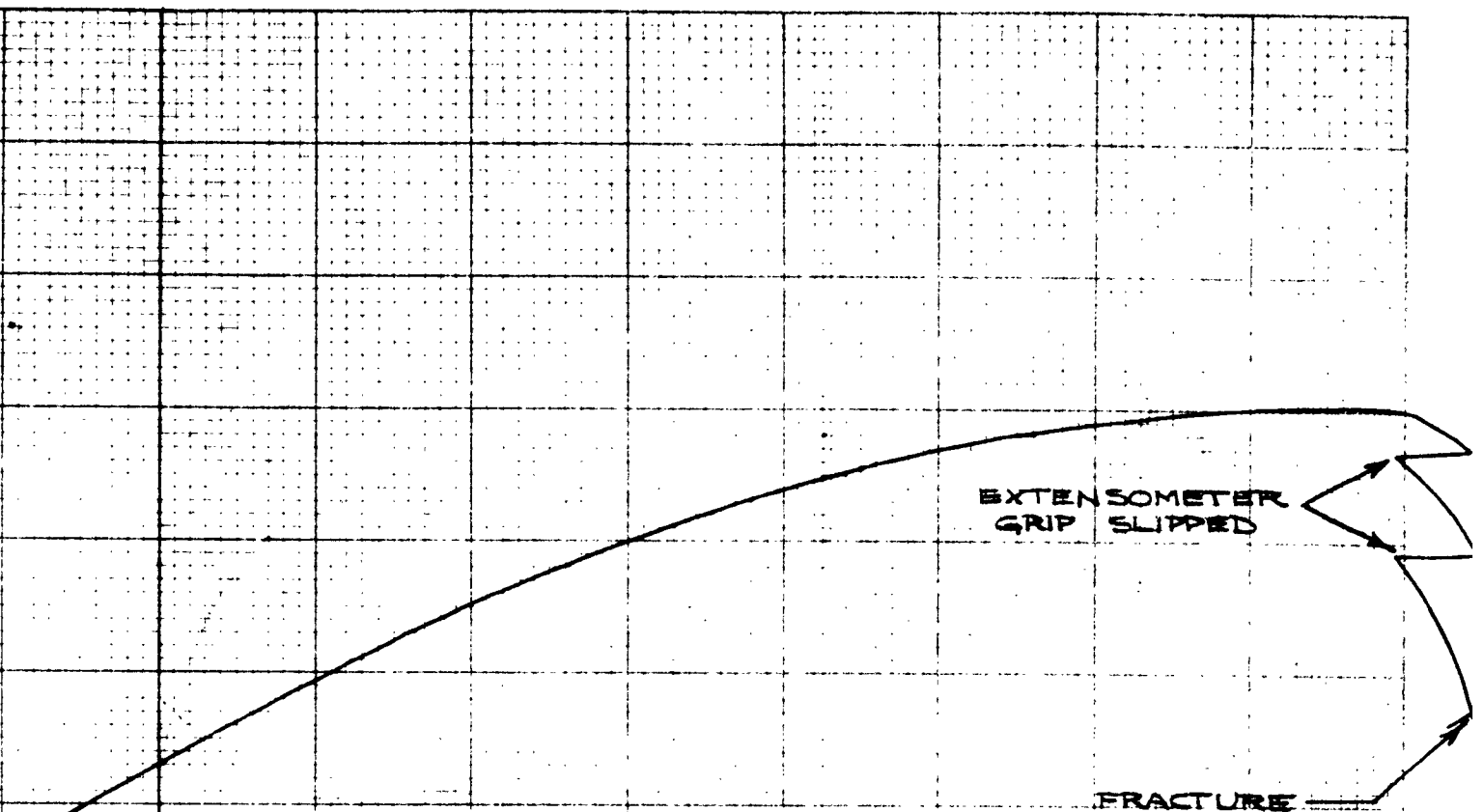
STRAIN (IN/IN)	STRAIN RATE (IN/IN/MIN)	LOAD RATE (LBF/MIN)	DISPLACEMENT (IN)
① .005	③ .005		
② .050	④ 0.10		

ELS 4/30/3 CPR

CHECK APP



For 120K machine only



2

	STRAIN	STRAIN RATE IN/IN/MIN	LOAD RATE LBS/MIN	ELONGATION %
①	.005	③ .005		
②	.050	④ 0.10		

THE BOEING COMPANY

NUMBER D2-80086 MODEL NO. X-20

TITLE NOSE LANDING GEAR ENERGY SYSTEM DEVELOPMENT

PREPARED BY	J. Grant	5/27/63
SUPERVISED BY	R. R. Logan	5/27/63
APPROVED BY	E. Baber	5-27-63
RELIABILITY APPROVAL		5-28-63 (DATE)

, A.K. Hopkins 6/4/63

AF33(657)-7132
CONTRACT NO.

5-76200-5590-05639-3-25353
CHARGE NUMBER

2-5142

SECTION TITLE PAGE U3 4288 0000 REV. 1/61

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3.1 SUMMARY

3.1.1 This report contains the results of impact, static, and rapid load testing of twelve (12) nose landing gear energy strap test specimens (full scale) and three (3) standard tensile specimens, all fabricated from the same heat of Inconel material.

3.1.2 The impact tests were conducted at specimen temperatures and impact velocities simulating three landing sink rates. Twelve (12) full-scale specimens were impact tested.

3.1.3 The static tests were conducted on three (3) full-scale strap specimens which had previously been impact tested at elevated temperatures and three (3) standard tensile specimens to determine maximum energy-absorbing capacities and Inconel basic tensile properties, respectively. The full-scale energy strap specimens were tested at elevated temperatures and the standard specimens were tested at room temperature and at .005 in/in/min strain rate.

3.1.4 The rapid load test was conducted on one (1) previously impact tested specimen at elevated temperature to determine total elongation and total energy to failure.

3.1.5 Impact tests results obtained included specimen load and deflection versus time curves, permanent angular displacement of the specimen pivot end (due to strap terminal-pin friction), and specimen elongation and section change over the specimen length.

3.1.6 Static test results obtained included load versus deflection curves for the three (3) energy strap specimens and load versus strain curves for the three (3) standard tensile specimens.

3.1.7 Rapid load test results obtained consisted of load and deflection data at elevated temperature.

3.2 TABLE OF CONTENTS

3.3 REFERENCES

3.3.1	Nose Landing Gear Energy System Development		EWA 5-639 [1]
3.3.2	Energy Straps (D/S) Installation (Test Only)		BAC 25-80333
3.3.3	Tensile Specimen Round		BAC 23-7070
3.3.4	Strap-Shock Absorber, Nose Landing Gear (Test Only)		BAC 29-80000
3.3.5	Figure 3.4, Energy Strap Test Specimen	Neg. No.	FA-2A95784
3.3.6	Figure 3.5, Rene' 41 Pivot Pin - Impact Test	Neg. No.	FA-2A95782
3.3.7	Figure 3.6, Pivot End - Impact Test Fixture	Neg. No.	FA-2A100537
3.3.8	Figure 3.7, Impact Test Setup - High Temperature Environment	Neg. No.	FA-2A95783
3.3.9	Figure 3.9, Impact Test Setup - High Temperature Environment	Neg. No.	FA-2A95350
3.3.10	Figure 3.10, Impact Test Setup - Low Temperature Environment	Neg. No.	FA-2A101036
3.3.11	Figure 3.11, Rapid Loading Test Setup	Neg. No.	FA-2A104409

[1] Refer to D2-6783-1 Structural Integrity Development and Test Program - Detail Plan - Structures Technology

3.4 INTRODUCTION

3.4.1 This report is the result of work accomplished on EWA 5-639,* Reference 3.3.1. The work was required to obtain energy-absorbing characteristics of a proposed nose landing gear energy strap configuration, fabricated from Inconel material, over the applicable range of landing temperatures and dynamic loading rates.

* Refer to D2-6783-1 Structural Integrity Development and Test Program - Detail Plan - Structures Technology

3.5 TEST SPECIMEN

3.5.1 The twelve (12) main gear energy strap impact load test specimens were fabricated per Reference 3.3.4. A sketch of the test specimens is shown in Figure 3.1, 3.3, and 3.4.

3.5.2 The six (6) static load test specimens consisted of three (3) of the previously impact tested specimens and three (3) standard tensile specimens fabricated per Reference 3.3.3. A sketch of the test specimens is shown in Figure 3.2.

3.5.3 The rapid load test specimen consisted of one (1) of the previously impact tested specimens.

3.5.4 All test specimens were fabricated from the same heat of 4" diameter Inconel bar, annealed at 1875 ±25°F for 30 minutes after machining and then air cooled.

3.6 TEST SETUP AND INSTRUMENTATION

3.6.1 The impact load test setup utilized a falling weight dropped from a predetermined height (based on initial strap impact velocity requirement) onto the lower part of the test fixture, which was covered with a one inch layer of high density styrofoam. The styrofoam layer had a compressive yield strength of 120 to 140 PSI and acted as a shock absorber. The induced load was transmitted by the test fixture to the pivot beam. The pivot beam, in turn, transferred the load through a Rene' 41 pivot pin to the terminal of the energy strap specimen. As the energy strap deflected under the impact load application, the pivot beam rotated through an angle of rotation that simulates movement between the energy strap and the landing gear strut during a landing impact condition.

3.6.2 The elevated temperature environment was obtained by surrounding the strap specimen with twelve (12) radiant heat lamps. The heat lamps were powered and controlled by an ignitron unit. The low temperature environment was obtained by applying carbon dioxide gas into a plywood box which encased the test specimen.

3.6.3 The impact load test instrumentation consisted of an electronic deflection indicator and a load cell to measure deflection and impact load and an oscillograph to record the load and deflection with a common time base. A high speed camera and a Vanguard analyzer were used to calibrate and check the oscillograph recording during the early phase of testing. Eight spot welded chromel-alumel thermocouples, equally spaced along the length of each specimen, were used to measure the temperature of the elevated temperature tested specimens. Three (3) chromel-alumel thermocouples, one (1) placed at the center and one (1) at each end, were used to measure the temperature of the low temperature tested specimens.

3.6.4 The three (3) standard tensile specimens tests were conducted in a 120,000 pound capacity Baldwin Universal test machine at room temperature. The machine was equipped with a model MD-2 autographic load-strain recorder. A Baldwin strain pacer was used to insure a proper average strain rate. The strain to failure was measured using a Baldwin TS-MD dual range extensometer.

3.6.5 Three (3) of the previously impact tested specimens (numbers 12, 13, and 14) were tested to failure in the one million pound capacity test machine at elevated temperatures. The elevated temperature environment was obtained by surrounding the strap specimen with radiant heat lamps. These heat lamps were powered and controlled by an ignitron unit.

3.6.6 The static load test instrumentation consisted of a 70,000 pound capacity load cell to measure load, a reel type deflection transducer to measure the pin-to-pin deflection, and an X-Y plotter and adaptor console to record load versus deflection. Four (4) spot welded chromel-alumel thermocouples equally spaced along the length of each specimen were used to measure specimen temperature.

3.6.7 The rapid rate deflection test setup consisted of a hydraulic bench, used in conjunction with accumulators, a servo valve, and needle valves, to actuate a hydraulic cylinder. The hydraulic cyclinder ram and fitting was attached to the energy strap through an adaptor. The elevated temperature environment of 800° F. was supplied by radiant heat lamps, powered and controlled by an ignitron unit.

3.6.8 Instrumentation consisted of a load cell and crescent deflection indicator to measure load and deflection. A record of load and deflection was provided by a Visicorder high speed strip chart recorder. Specimen temperature was measured by spot welded chromel-alumel thermocouples equally spaced along the length of each specimen.

3.7 TEST PROCEDURE

3.7.1 In order to meet the required impact test load parameters as tabulated in Table 3.1, several trial runs were conducted with simulated test specimens installed in the test system. The strap load-deflection data obtained from these runs were used to determine the energy output characteristics of the test system.

3.7.2 The actual specimen being impact tested was then placed in the test setup with a new oxidized Rene' 41 pin installed for each test to simulate actual operating condition. The specimen was brought to the required stabilized temperature over the specimen length, the weight was dropped, and the following data obtained:

1. Strap load versus time.
2. Strap deflection versus time.
3. Angular displacement of the strap pivot end.
4. Elongation of measured sections of the strap.
5. Change of diameter at various sections along the strap length.

3.7.3 The static test specimens were placed in a universal test machine and tested to failure. Strain versus load was recorded for the standard tensile specimens and load versus deflection was recorded for the three (3) previously impact tested specimens.

3.7.4 The rapid rate deflection test specimen was placed in the test setup, heated until a stabilized temperature of 800° F. was obtained over the full length, and loaded by a quick acting hydraulic actuator. Load and deflection data was recorded.

3.8 TEST RESULTS

3.8.1 Maximum impact strap load, impact strap energy, and strap per cent elongation are tabulated on pages 3-10 thru 3-12. Angular displacement of the pivot end is shown on page 3-13. Load versus time, deflection versus time, and load versus deflection curves are shown on pages 3-26 through 3-49.

3.8.2 Static test results showing ultimate and yield strength are tabulated on pages 3-14 and 3-15. Static load versus deflection curves, for the previously impact tested specimens, are shown on pages 3-50 through 3-52. Static load versus strain curves for the standard tensile specimens are shown on pages 3-53 through 3-55.

3.8.3 Rapid rate deflection test results are shown on page 3-14. Load versus deflection curve is shown on page 3-56.

3.9 TEST OBSERVATIONS

3.9.1 Impact tests were satisfactorily completed on the nose gear energy straps. Equipment functioned properly and data was recorded for each test.

3.9.2 All specimens tested to failure in the Universal Test Machine produced satisfactory data.

3.9.3 One specimen was tested in the rapid-rate load setup. Equipment functioned properly and satisfactory data was obtained.

TABLE 3.1
REQUIRED IMPACT TEST PARAMETERS
(REFERENCE 3.3.1)

Temperature at °F	-65	72	600	600	600
Gear Impact Velocity (FT/SEC)	17	17	12	17	17
Strap Impact Velocity (FT/SEC)	20.3	20.3	14.3	20.3	20.3
Strap Energy Input (FT-LB)	32,600	32,600	16,200	32,600	32,600

TABLE 3.1

REQUIRED IMPACT
TEST PARAMETERS

PART NO.			29-80000-2			
SPECIMEN NO.			7	8	9	10
TEST RESULTS						
TEMP. - °F		2	600	600	72	72
WEIGHT DROP - LBS.		2	4860	4860	4860	4860
DISTANCE OF DROP - INCH		2	44	41.3	76	76
STRAP IMPACT VEL - FT/SEC.		3	14.3	14.3	20.3	20.3
STRAP IMPACT VEL FT/SEC.		4	15.4	14.9	20.2	20.2
STRAP DEFLECTION (MAX.) - INCH		2	6.31	5.56	6.70	6.72
ANGULAR ROTATION OF PIVOT BEAM ($\prec$) - DEG.	5	2	30.7	27.0	31.6	31.7
TOTAL INPUT ENERGY OF THE SYSTEM FT-LB	6	4	20,752	19,310	33,893	33,902
STRAP ENERGY INPUT (RECORD) - FT-LBS.	1	2	18,200	16,609	26,914	27,236
STRAP MAX. IMPACT LOAD - KIPS		2	45.4	47.2	63.5	62.8

1> STRAP ENERGY INPUT WAS OBTAINED FROM THE AREA UNDER THE LOAD-DEFL

2> MEASURED DATA

3> REQUIRED DATA (SEE TABLE 2.1)

4> CALCULATED DATA AS FOLLOWS:

$$V = \sqrt{2gH/6}$$

$$E_{CAL} = \frac{W_1H+(W_1+W_2)\Delta}{12}$$

WHERE V - IS THE VELOCITY OF THE FALLING BODY AT IMPACT.
H - IS THE DISTANCE THE FALLING BODY WILL DROP BEFORE IMPACT.
E_{CAL} - IS THE TOTAL INPUT ENERGY OF THE SYSTEM.
W_1 - IS THE WEIGHT OF THE FALLING BODY.
W_2 - IS THE WEIGHT OF THE TEST FIXTURE.
Δ - IS THE DEFLECTION OF THE TEST SPECIMEN

5> SEE PAGE 3-23 FOR LOCATION OF ANGLE ($\prec$)

6> THE ENERGY LOSS IN THE SYSTEM WAS DUE TO THE FOLLOWING:
1) FRICTION BETWEEN THE FALLING WEIGHT AND THE TEST FIXTURE. (AND)
2) CRUSHING OF THE STYROFOAM LAYER ON THE TEST FIXTURE BASE PLATE AT IMPACT.

1

CALC	
CHECK	
APR	
APR	

NOSE GEAR ENERGY STRAPS

29-80000-2				29-80000-3	29-80000-2				29-80000-3		
7	8	9	10	11	12	13	14	15	16	17	18
600	600	72	72	72	600	600	800	800	72	-65	-65
4860	4860	4860	4860	4860	5275	5275	5275	5275	5275	5275	5275
44	41.3	76	76	76	79	79	79	79	79	79	79
14.3	14.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3
15.4	14.9	20.2	20.2	20.2	20.6	20.6	20.6	20.6	20.6	20.6	20.6
6.31	5.56	6.70	6.72	8.10	9.43	9.06	9.78	9.06	9.80	8.96	8.60
30.7	27.0	31.6	31.7	38.4	45.1	43.2	46.8	43.2	47.0	42.8	41.0
20,752	19,310	33,893	33,902	34,543	39,434	39,230	39,609	39,250	39,619	39,200	39,020
18,200	16,609	26,914	27,236	28,496	33,029	32,983	33,323	32,877	33,459	33,263	32,561
45.4	47.2	63.5	62.8	54.4	55.5	58.0	54.8	57.8	53.0	57.3	58.0

FROM THE AREA UNDER THE LOAD-DEFLECTION CURVE ON PAGE 3-26 THRU 3-49

BODY AT IMPACT.
T WILL DROP BEFORE IMPACT.
E SYSTEM.
DY.
RE.
PECIMEN

NGLE (α)

AS DUE

ING WEIGHT
ED)
LAYER
PLATE

2

CALC J.Lobo		REVISED	DATE	TABLE 3.2 IMPACT TEST RESULTS X-20 NOSE LANDING GEAR	X-20
CHECK Grant					D2-80086
APR					
APR				THE BOEING COMPANY	PAGE 3-10

FOR MEASUREMENT LOCATION SEE FIGURE 3.3 (symbol 1)

$$\% \text{ DIFF} = \frac{\text{CHANGE OF SECTION LENGTH}}{\text{ORIGINAL LENGTH OF SECTION}}$$

SPECIMEN NO.		'A' (1)	'B' (1)	'C' (1)	'D' (1)	'E' (1)	'F' (1)	'G' (1)
7	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF	+7.6	+19.0	+17.0	+16.6	+17.0	+19.6	+19.6
8	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF.	+6.2	+14.6	+15.0	+15.4	+15.6	+15.4	+13.6
9	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF	+11.2	+18.8	+18.8	+20.0	+20.0	+20.0	+20.0
10	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF	+8.6	+18.8	+18.8	+19.2	+19.2	+19.2	+20.0
11	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF.	+10.6	+22.4	+23.6	+21.2	+23.6	+23.6	+25.0
12	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF	+15.0	+27.6	+27.6	+27.6	+27.6	+27.6	+27.6
13	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF	+15.0	+25.0	+27.6	+30.0	+25.0	+25.0	+20.0
14	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF.	+15.0	+30.0	+30.0	+30.0	+30.0	+30.0	+30.0
15	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF.	+15.0	+25.0	+25.0	+25.0	+25.0	+25.0	+25.0
16	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF.	+15.0	+27.6	+27.6	+27.6	+27.6	+27.6	+27.6
17	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF.	+10.0	+24.0	+24.0	+24.0	+24.0	+24.0	+24.0
18	DISTANCE	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	% DIFF.	+15.6	+25.0	+25.0	+25.0	+25.0	+25.0	+25.0

CALC	[signature]	5/1/7[illegible]	REVISED	DATE	TABLE 3.3 MAIN GEAR ENERGY STRAP SECTION LENGTHS AND PERCENT ELONGATION AFTER IMPACT TEST	X-20
CHECK	[signature]					D2-80036
APR					THE BOEING COMPANY	PAGE 3-11
APR						

U3 4041 9000

▷1 FOR MEASURMENT LOCATION SEE FIGURE 3.3.

$$\% \text{ DIFF} = \frac{\text{CHANGE OF SECTION DIAMETER}}{\text{ORIGINAL DIAMETER OF SECTION}}$$

SPECIMEN NO.		'A1' ▷1	'B1' ▷1	'C1' ▷1	'D1' ▷1	'E1' ▷1	'F1' ▷1	'G1' ▷1
7	DIA.	.990	.990	.988	.989	.989	.989	.991
	% DIFF.	-7.78	-7.47	-7.69	-7.79	-7.79	-7.79	-5.85
8	DIA.	.9903	.9905	.9890	.9882	.9890	.9887	.9910
	% DIFF	-6.80	-6.61	-7.18	-6.70	-7.18	-7.15	-5.55
9	DIA	.987	.987	.986	.987	.987	.988	.989
	% DIFF.	-8.31	-8.21	-842	-8.51	-8.31	-8.40	8.80
10	DIA	.986	.985	.986	.985	.983	.985	.988
	% DIFF.	-8.42	-8.53	-8.52	-8.63	-8.75	-8.63	-9.21
11	DIA	.883	.883	.883	.881	.880	.880	.879
	% DIFF.	-9.74	-9.74	-10.08	-10.22	-10.34	-10.45	-10.35
12	DIA	.986	.987	.988	.988	.987	.977	.985
	% DIFF.	-11.26	-11.14	-11.23	-10.73	-11.14	-11.16	-9.75
13	DIA	.989	.989	.987	.985	.987	.989	.988
	% DIFF	-11.02	-10.72	-11.55	-10.76	-10.84	-10.41	-10.32
14	DIA.	.985	.987	.987	.985	.987	.988	.985
	% DIFF	-12.49	-11.34	-11.85	-11.78	-11.75	-11.23	-8.53
15	DIA.	.988	.989	.988	.987	.987	.987	.987
	% DIFF	-11.03	-10.92	-10.83	-10.64	-10.64	-10.64	-8.21
16	DIA.	.879	.880	.878	.879	.880	.883	.880
	% DIFF.	-10.35	-10.80	-11.39	-11.26	-11.36	-11.78	-10.23
17	DIA.	.883	.883	.884	.885	.884	.884	.884
	% DIFF	-11.21	-10.99	-10.86	-10.40	-10.29	-10.29	-10.41
18	DIA.	.882	.882	.883	.883	.882	.882	.883
	% DIFF.	-10.20	-9.86	-9.85	-9.85	-9.86	-9.98	-10.31

CALC	Grant	5/1/3	REVISED	DATE	TABLE 3.4 MAIN GEAR ENERGY STRAP DIAMETER AND PER-CENT CHANGE AFTER IMPACT TEST.	X-20
CHECK	Anderson					D2-80086
APR					THE BOEING COMPANY	PAGE 3-12
APR						

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SPECIMEN NO.	ANGLE θ (DEGREES)	DEFLECTION "A" (INCHES)
7	5.5	.30
8	8.9	.47
9	3.5	.17
10	10.25	.56
11	9.25	.44
12	9.8	.45
13	8.25	.39
14	10.0	.48
15	8.8	.44
16	7.5	.30
17	5.0	.24
18	7.5	.35

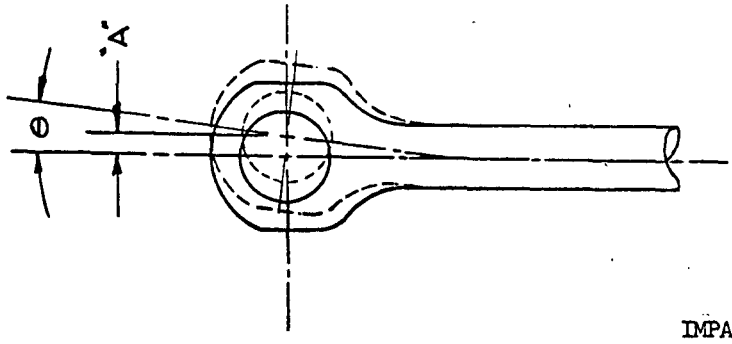


TABLE 3.5

IMPACT TEST RESULTS
PERMANENT ANGULAR DISPLACEMENT
OF STRAP PIVOT END

TABLE 3.6

SPECIMEN NUMBER	SPECIMEN LENGTH BEFORE IMPACT TEST (INCHES)	SPECIMEN LENGTH BEFORE STATIC OR RAPID RATE TEST (INCHES)	FINAL LENGTH AFTER STATIC OR RAPID RATE TEST (INCHES)	TEMP. °F	DEFLECTION RATE (IN/MIN)
12	38.80	47.72	54.61	600	2.5
13	38.80	47.34	54.65	600	2.5
14	38.80	48.28	55.65	800	2.5
15 [1]	38.80	47.44	52.24	800	510.

SPECIMEN NUMBER	ENERGY ABSORBED DURING IMPACT TEST (FT-LBS)	ENERGY ABSORBED DURING STATIC OR RAPID RATE TEST (FT-LBS)	TOTAL ENERGY ABSORBED (FT-LBS)
12	33,030	26,450	59,480
13	32,980	33,670	66,650
14	33,320	32,680	66,000
15 [1]	32,880	15,520	48,400

PREVIOUSLY IMPACT TESTED STRAP SPECIMENS
(REFERENCE PAGES 3-50 THRU 3-52 FOR STATIC TEST DATA)
(REFERENCE PAGE 3-56 FOR RAPID RATE TEST DATA)

[1] RAPID RATE DEFLECTION TEST

TABLE 3.6
STATIC AND RAPID RATE TEST RESULTS

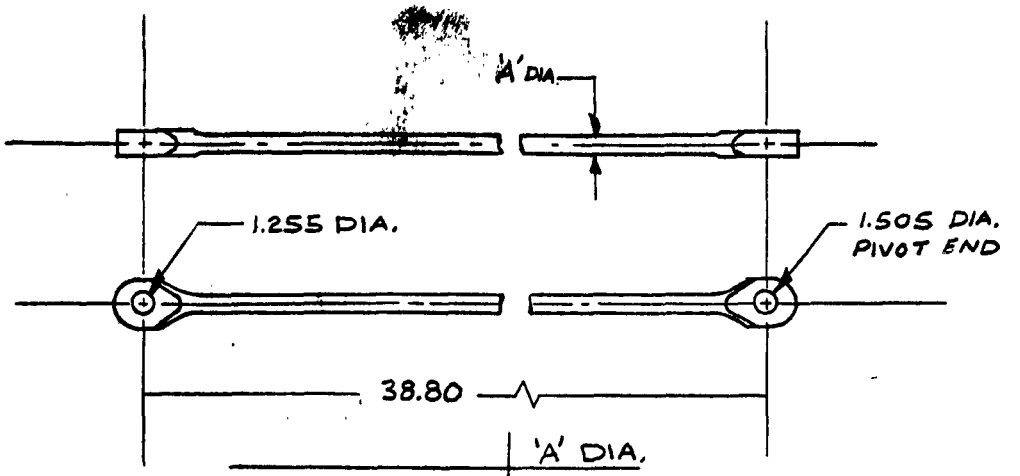
SPECIMEN NO.	ATMOSPHERE	GRAIN DIRECTION	TEST TEMP. °F	ULTIMATE STRENGTH (PSI)	YIELD STRENGTH (PSI)	ELONGATION % PER 2 INCHES
4-1 ▷1	AIR	LONG-ITUDINAL	74	95,700	36,700	48
4-2 ▷1	AIR	LONG-ITUDINAL	74	92,900	34,700	50
4-3 ▷1	AIR	LONG-ITUDINAL	74	92,900	34,300	50

▷1 STANDARD TENSILE ROUND TEST SPECIMEN.
(REFERENCE PAGES 3-53 THRU 3-55 FOR STRESS STRAIN CURVES.)

TABLE 3.7

STATIC TEST RESULTS
STANDARD TENSILE SPECIMENS

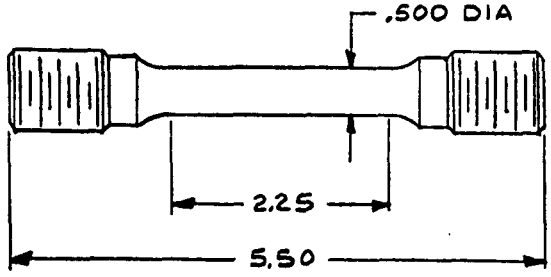
FIGURE 3.1



	'A' DIA.
RE-ENTRY (-2)	.980
AIR DROP (-3)	.875

STRAP SHOCK ABSORBER NOSE LANDING GEAR
SPECIMEN NUMBER 29-80000-2 & 29-80000-3

FIGURE 3.2



TENSILE SPECIMEN ROUND
SPECIMEN NUMBER 23-7070

FIGURE 3.1 & 3.2
TEST SPECIMEN

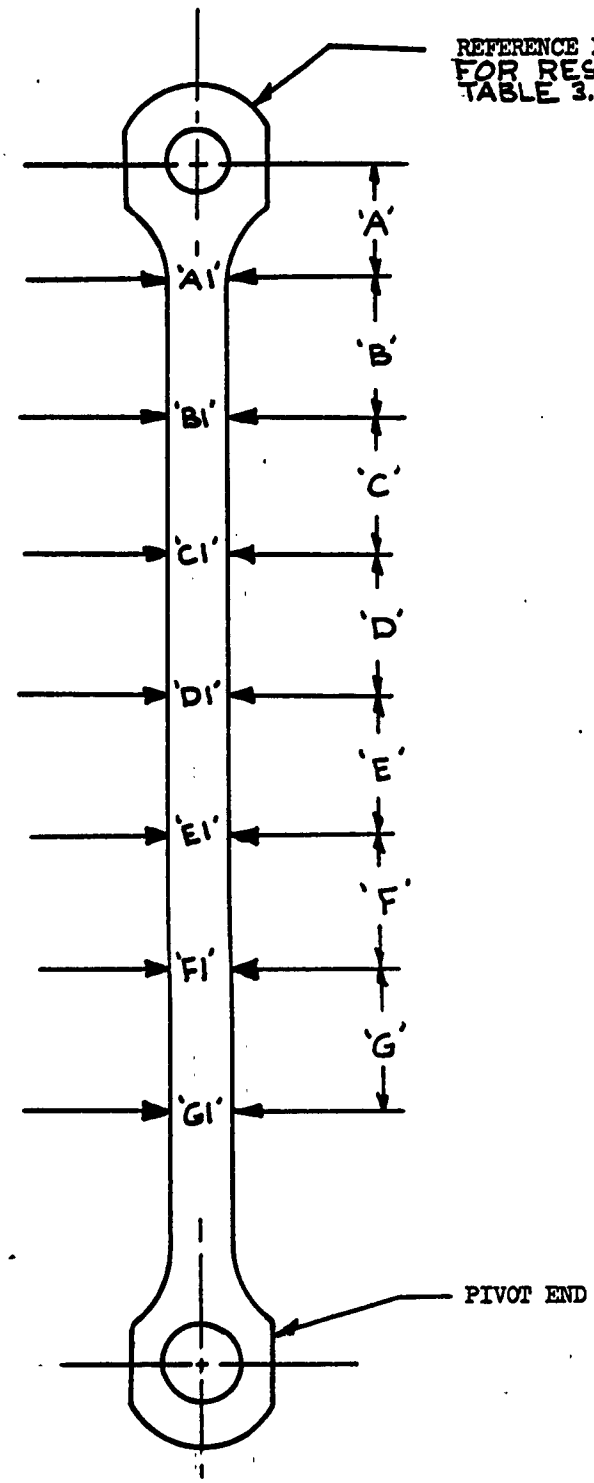


FIGURE 3.3

SECTION ELONGATION AND DIAMETER MEASUREMENT LOCATION (SKETCH)

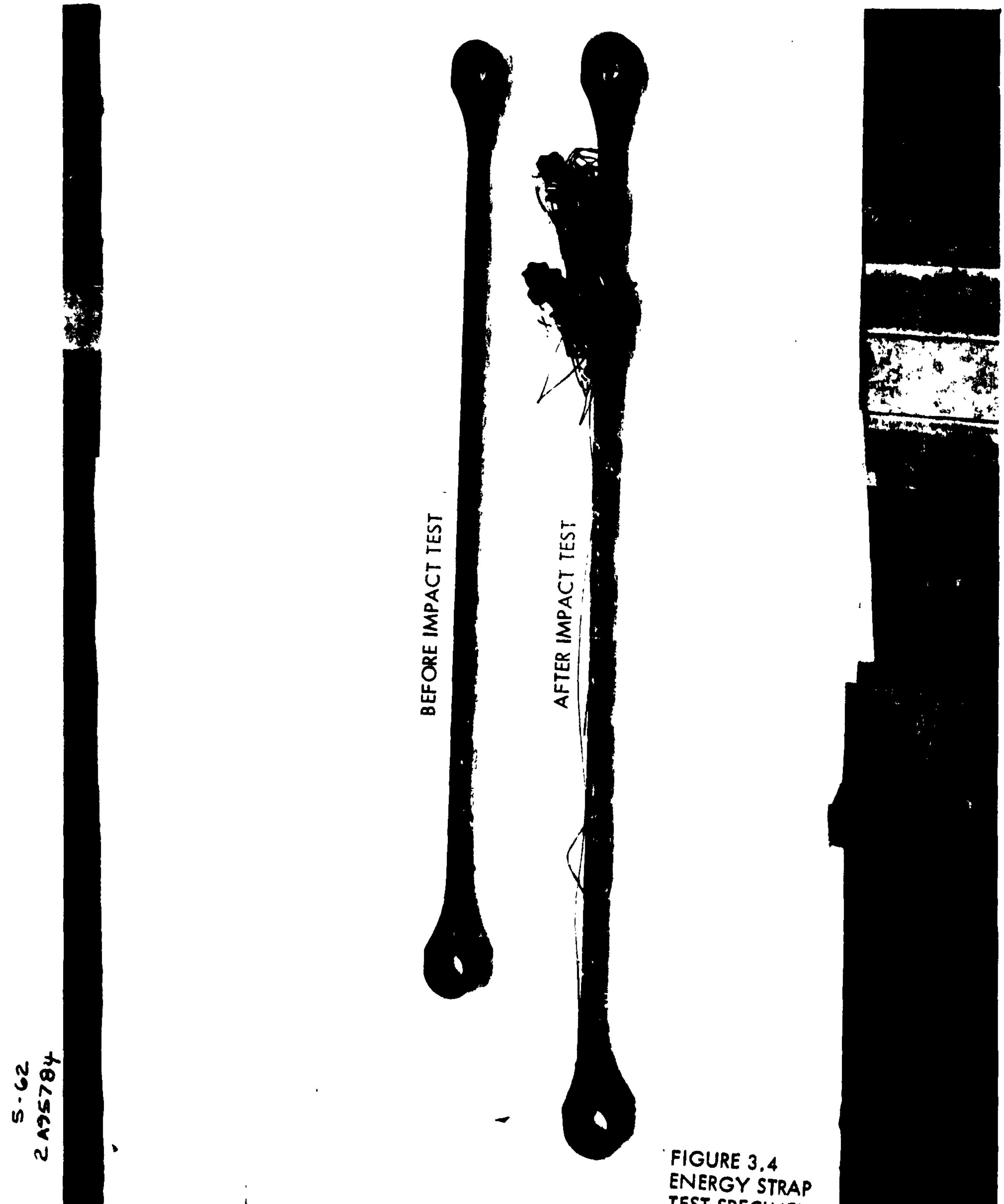


FIGURE 3.4
ENERGY STRAP
TEST SPECIMEN

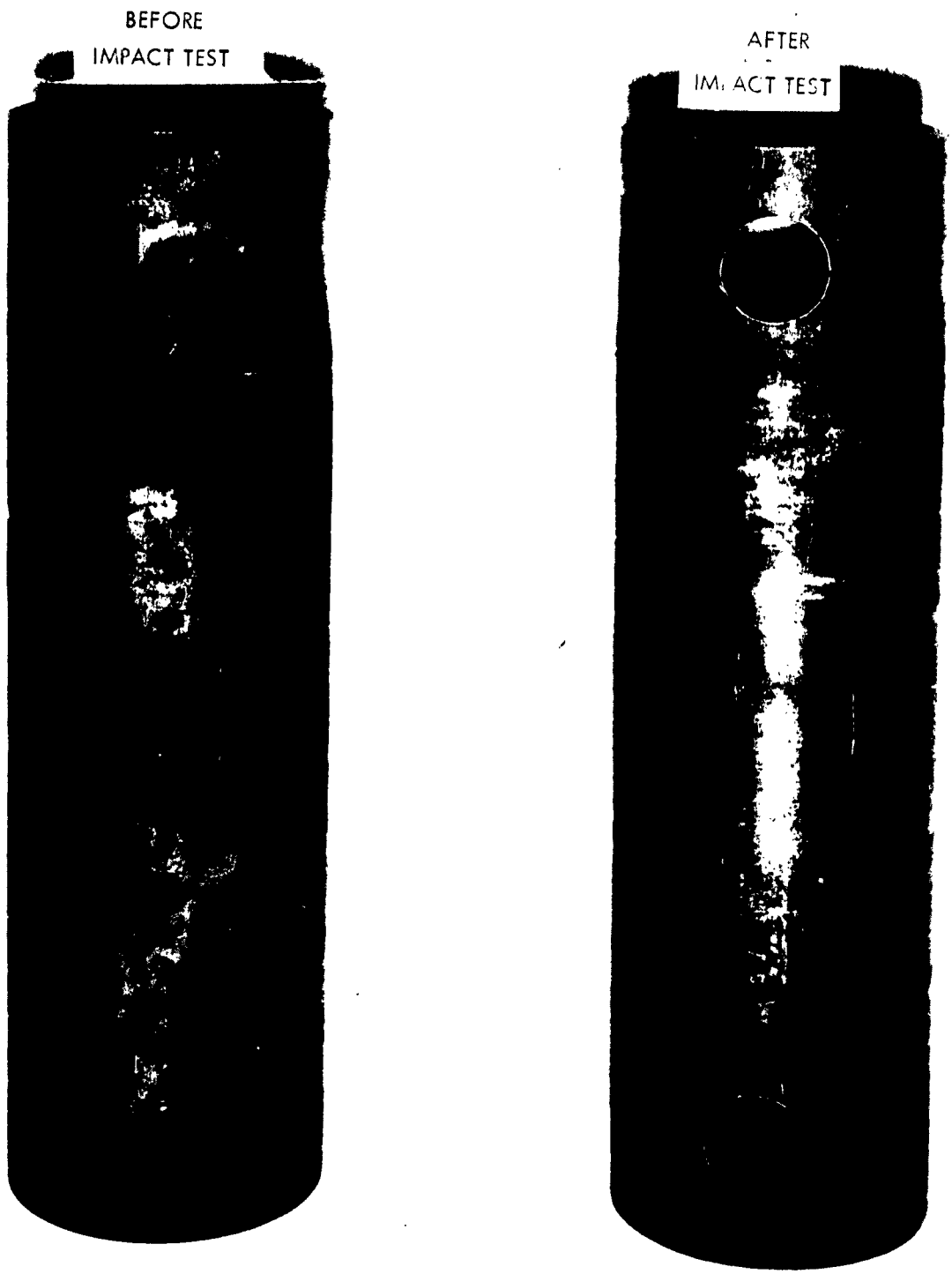


FIGURE 3,5
RENE' 41 PIVOT PIN

2495782
-5-62

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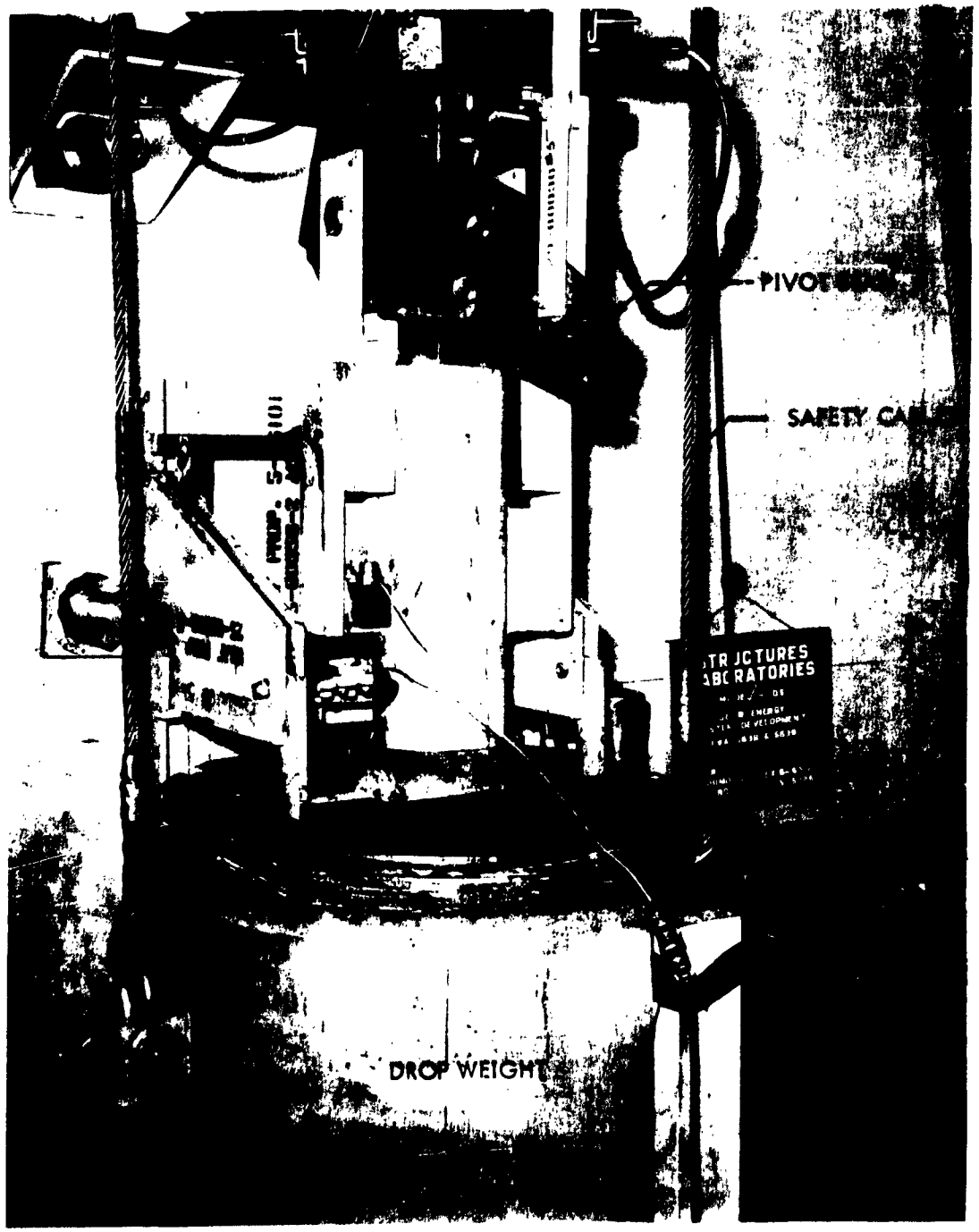

FIGURE 3.6
PIVOT END TEST FIXTURE

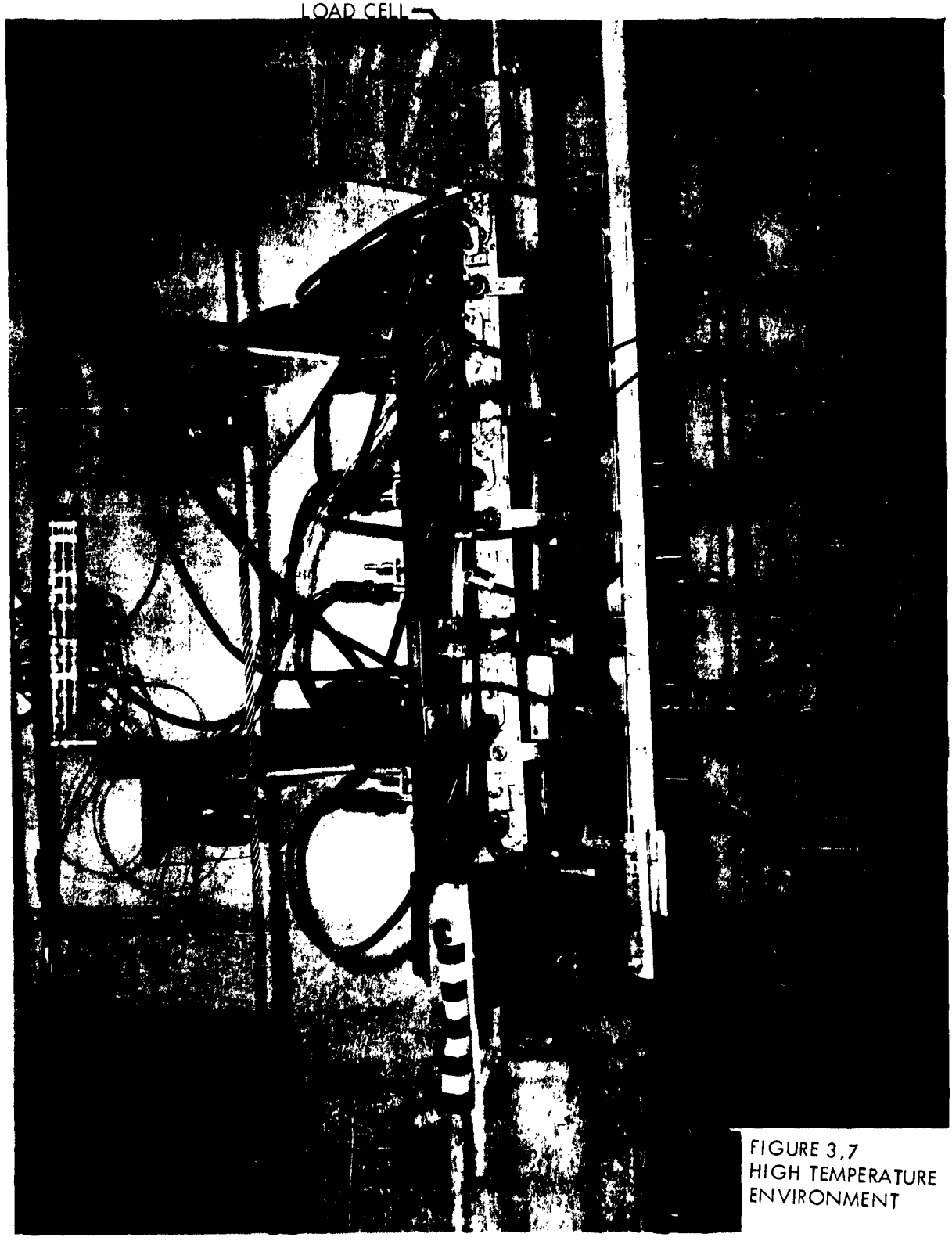

FIGURE 3,7
HIGH TEMPERATURE
ENVIRONMENT

~495783
·5-62

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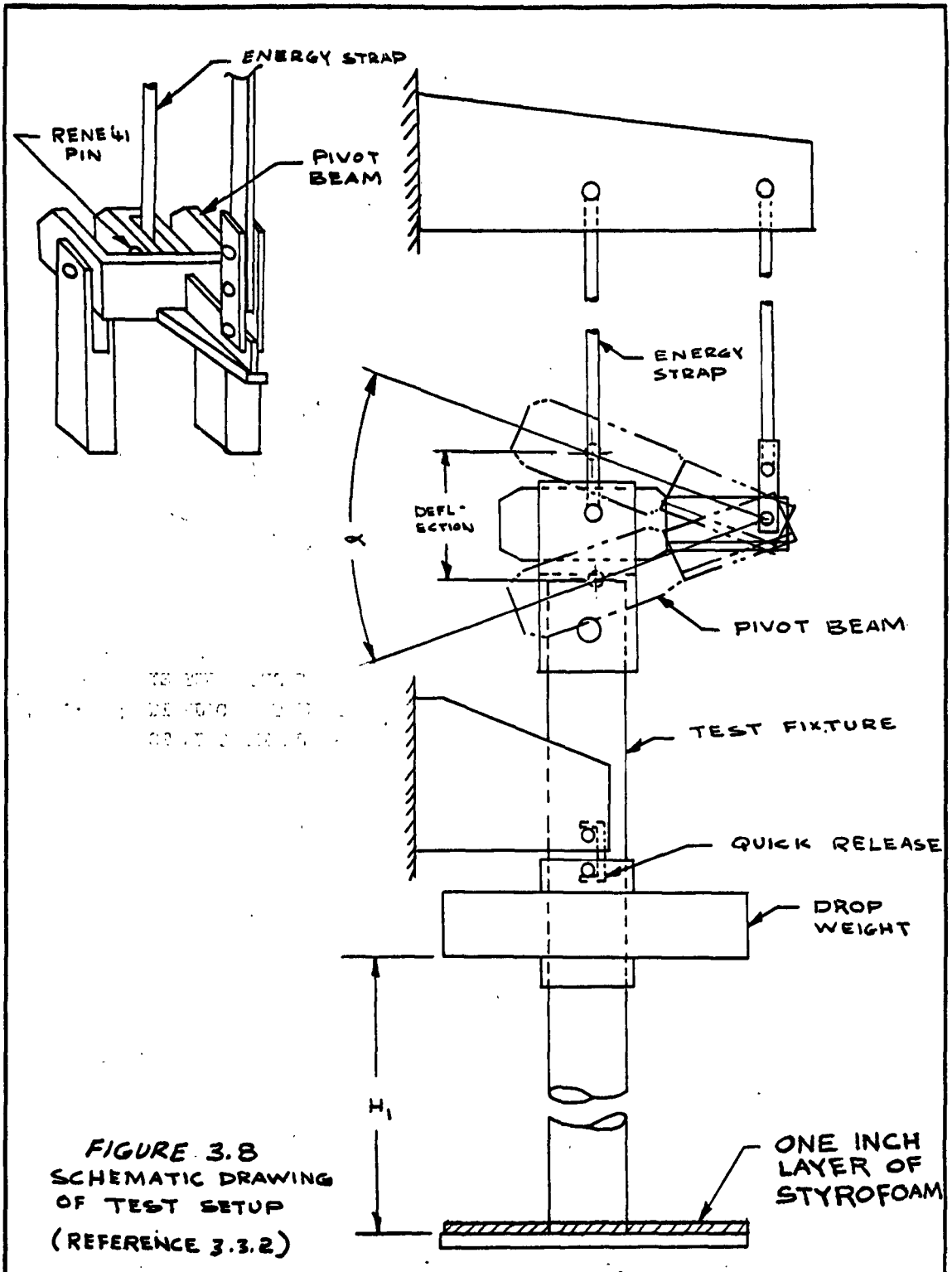


FIGURE 3.8
SCHEMATIC DRAWING OF TEST SETUP
(REFERENCE 3.3.2)

FIGURE 3.8

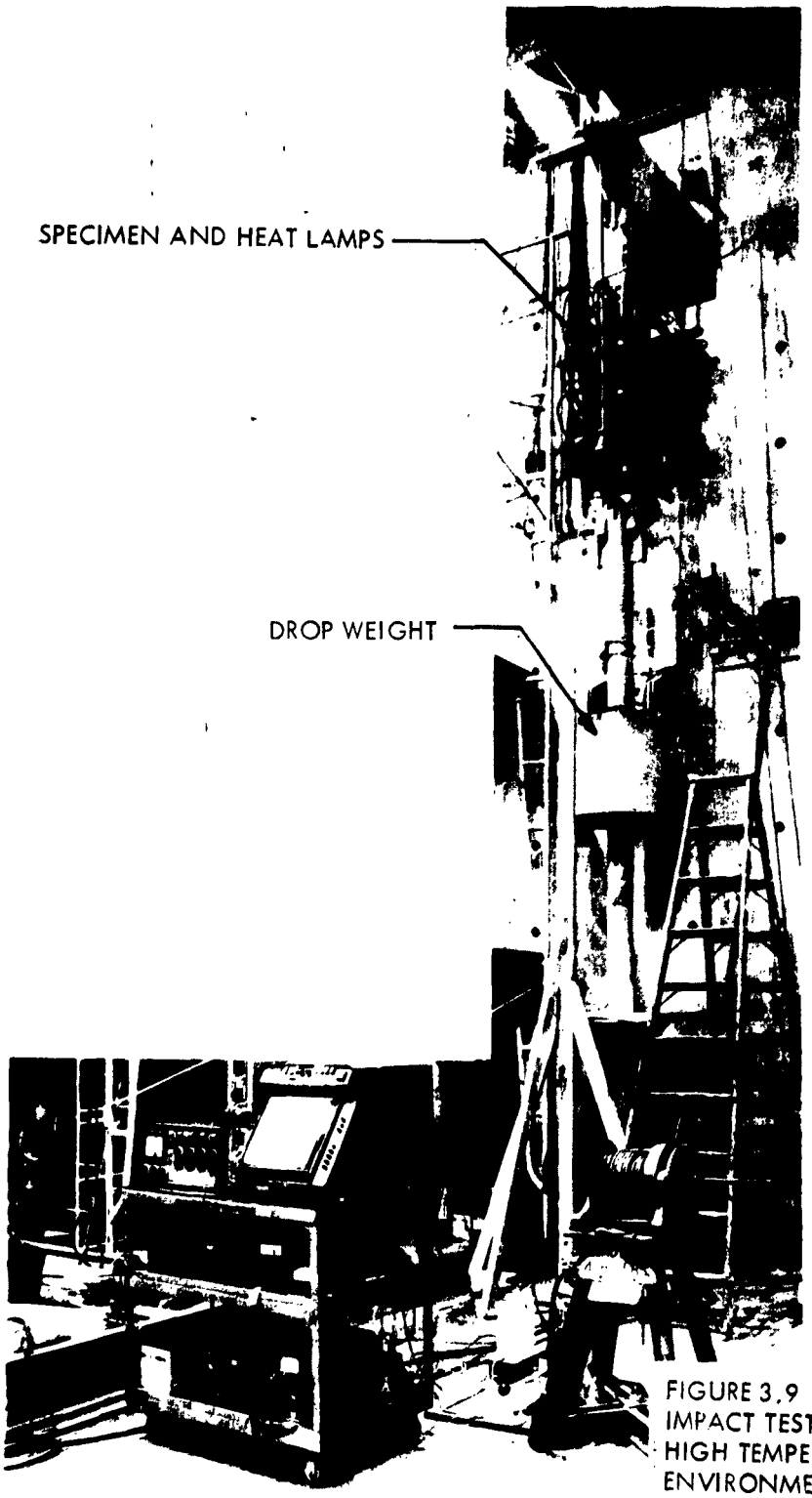


FIGURE 3.9
IMPACT TEST SETUP
HIGH TEMPERATURE
ENVIRONMENT

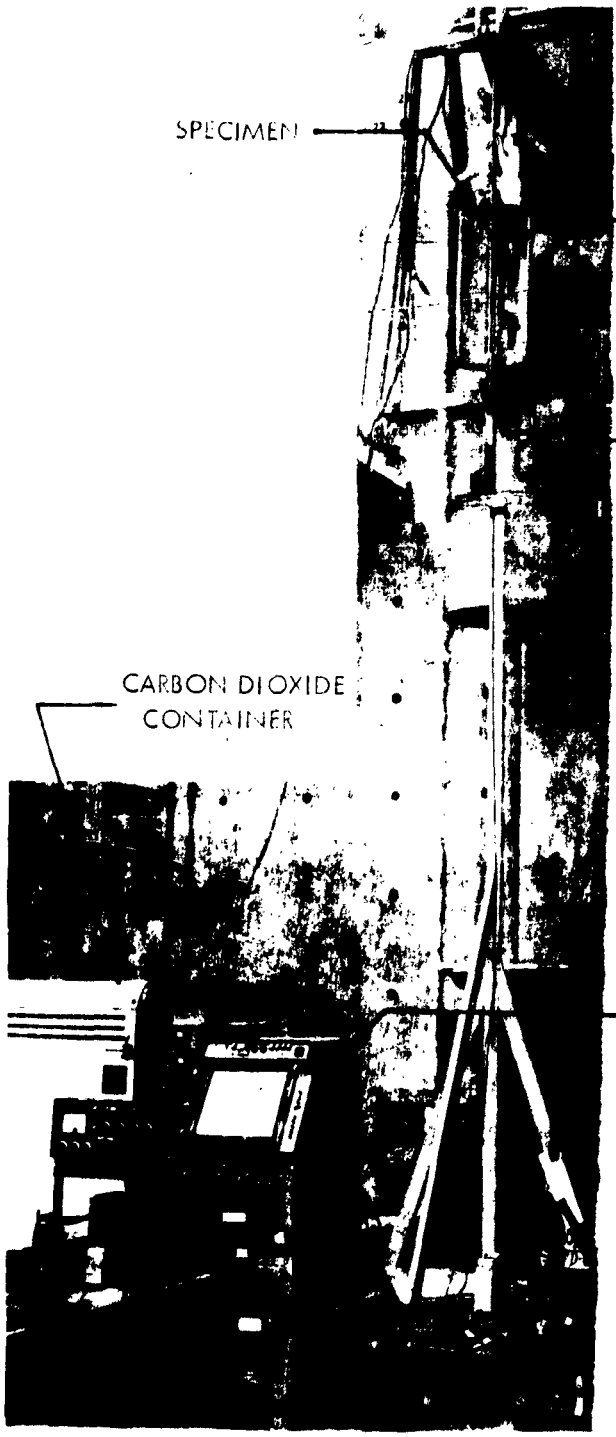
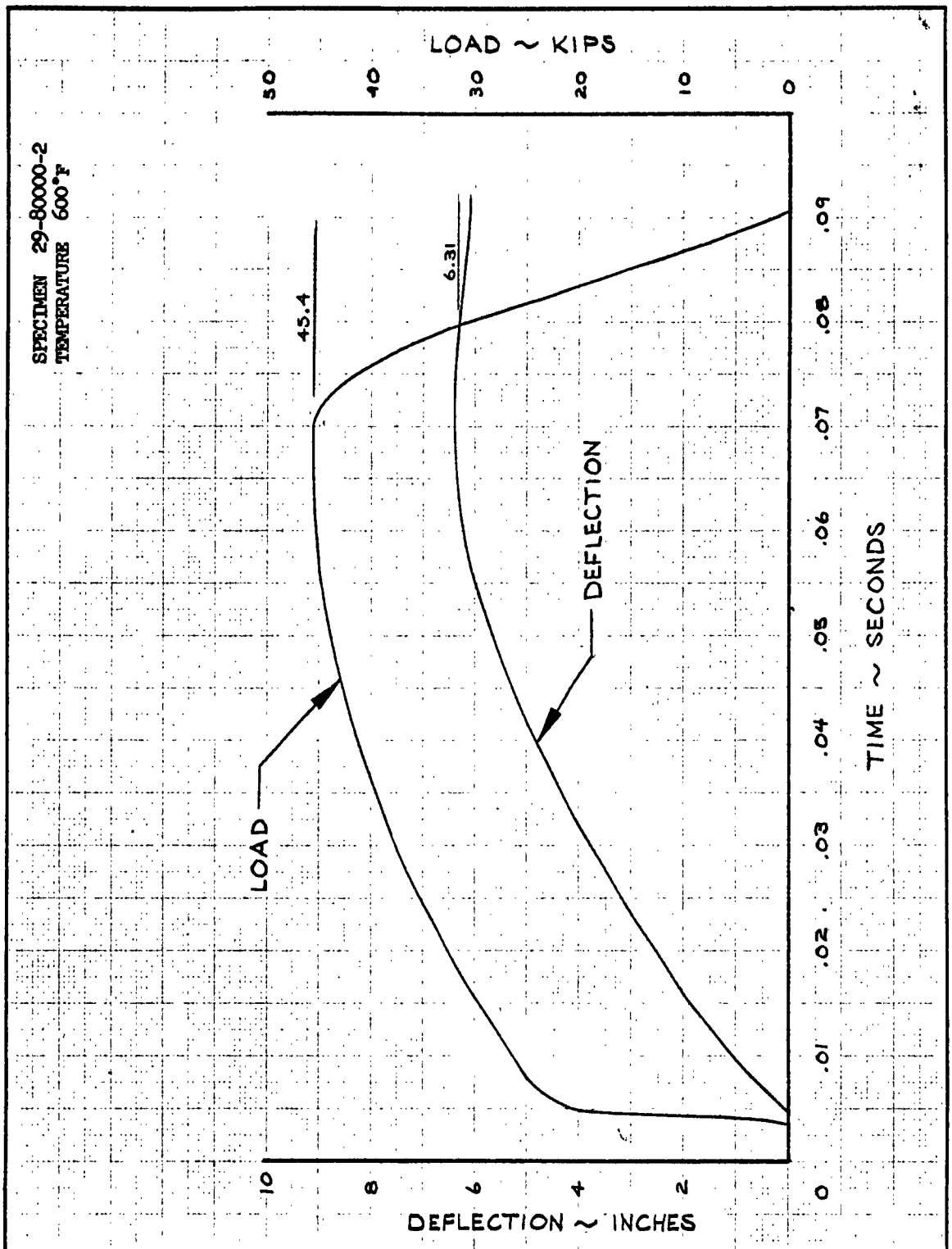


FIGURE 3.10
IMPACT TEST SETUP
LOW TEMPERATURE
ENVIRONMENT

FIGURE 3.11
RAPID LOADING
TEST SETUP



CALC	J.Lebo	1-2-2	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 7	X-20
CHECK	Jorgensen	1-9-2				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-26

US 4018 8000

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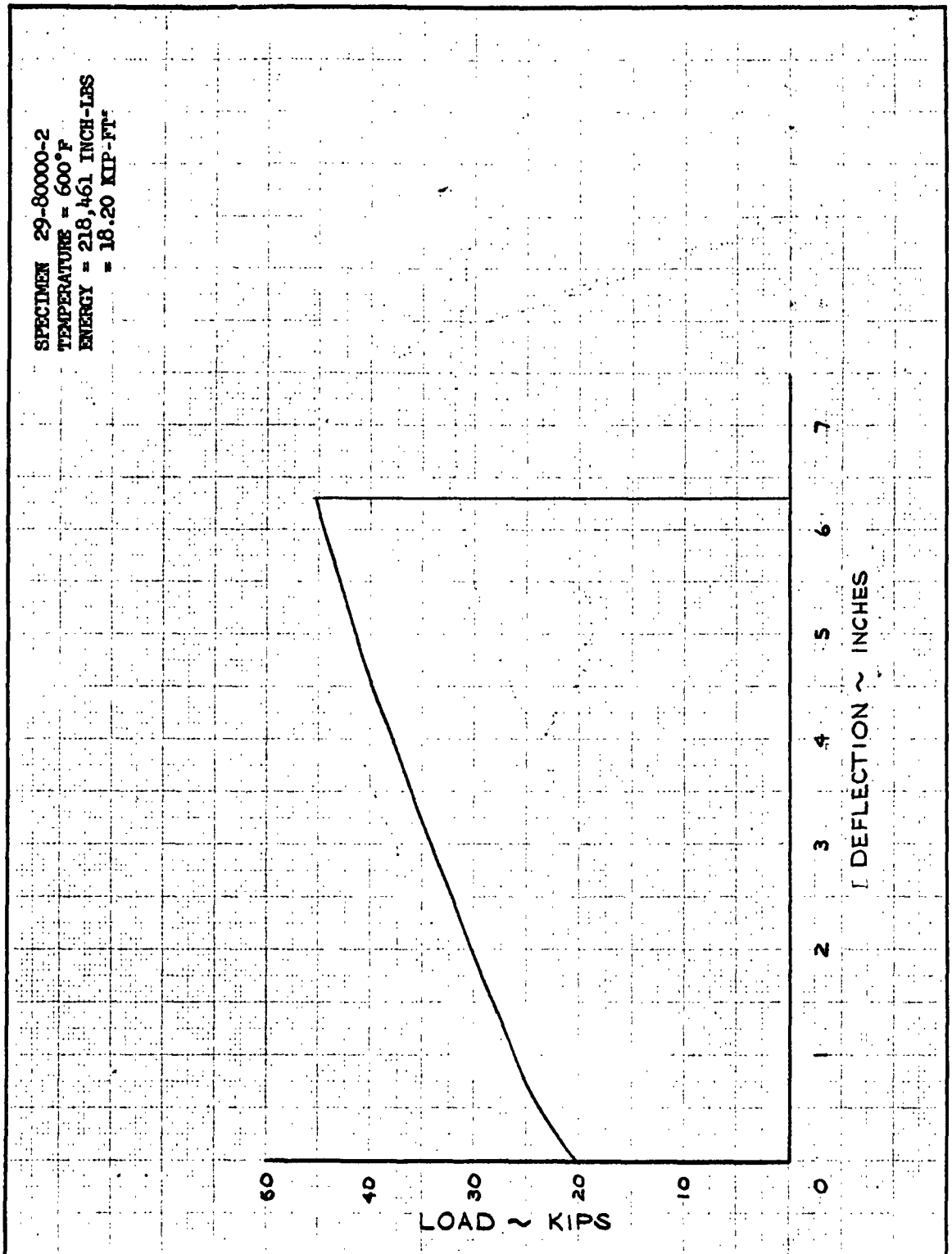
SPECIMEN 29-80000-2
TEMPERATURE = 600°F
ENERGY = 218,461 INCH-LBS
= 18.20 KIP-FT²



CALC	J.Lebo	1-2-2	REVISED	DATE
CHECK	Jorgensen	1-9-2		
APR				
APR				

LOAD VS DEFLECTION
SPECIMEN NO. 7

X-20
D2-80086

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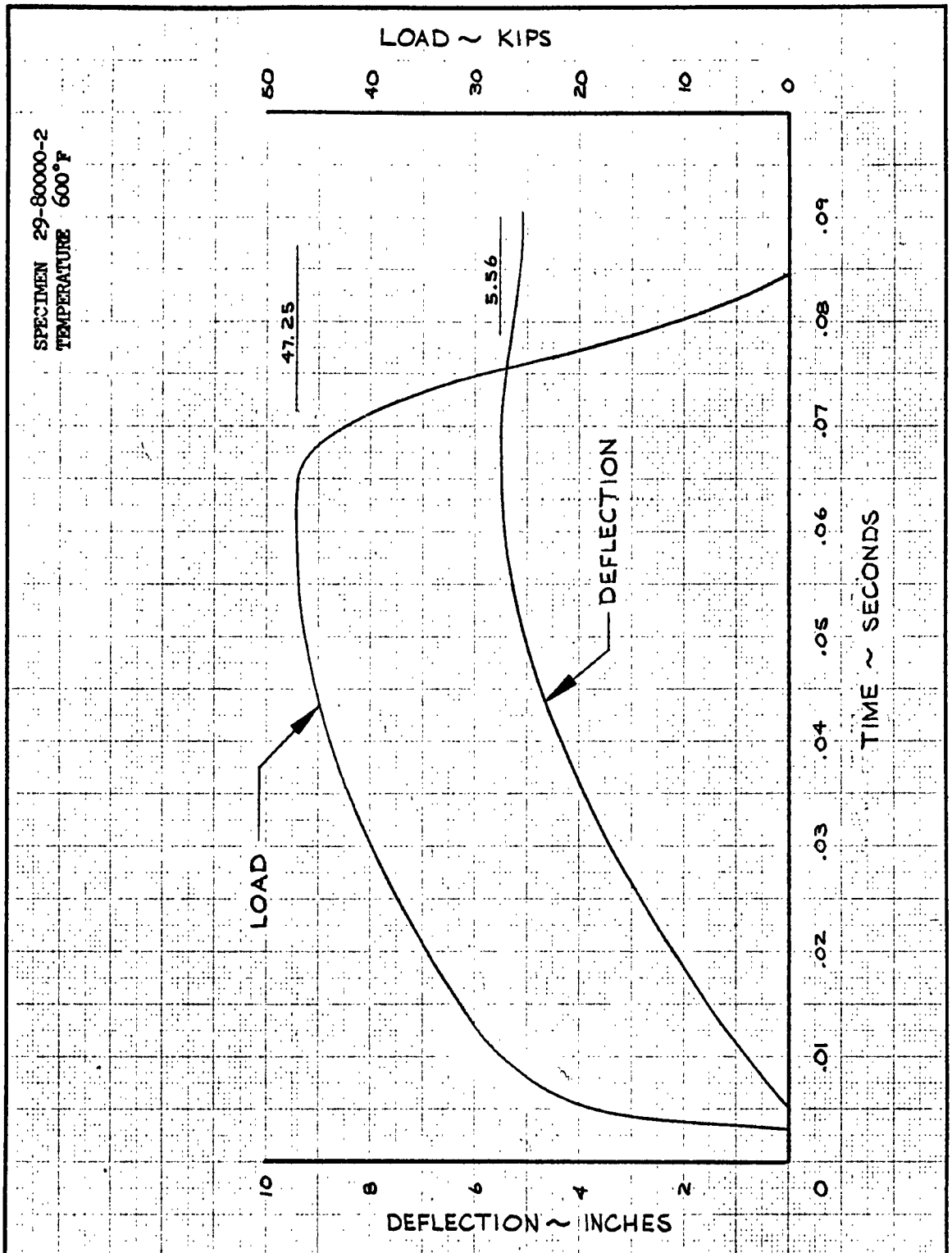
PAGE 3-27



CALC	J.Iebo	1-8-2	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 8	X-20
CHECK	Jorgensen	1-11-2				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-28

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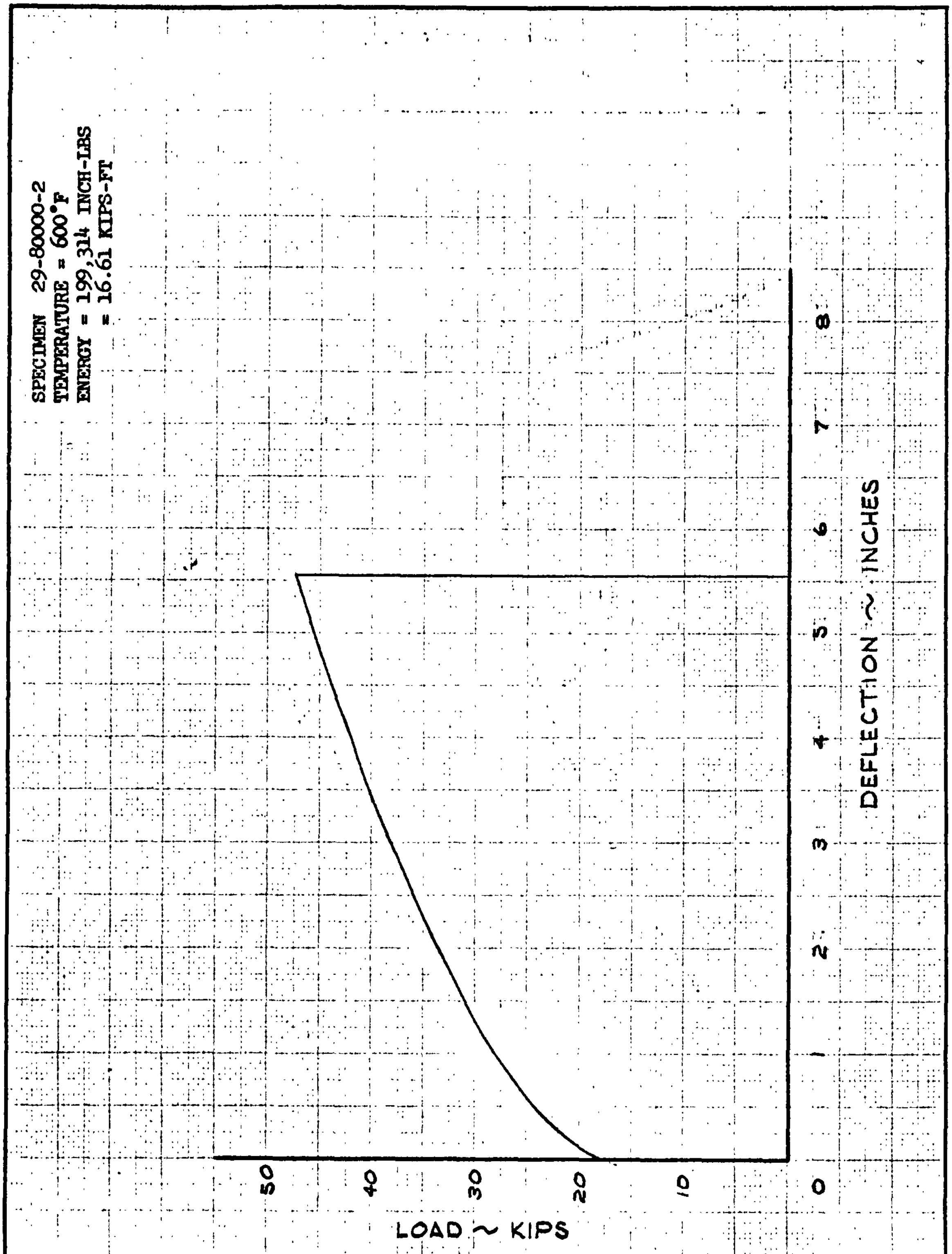

CALC	J.Lebo	1-8-2	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 8	X-20
CHECK	H.Jorgensen	1-11-2				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-29

US 4013 8000

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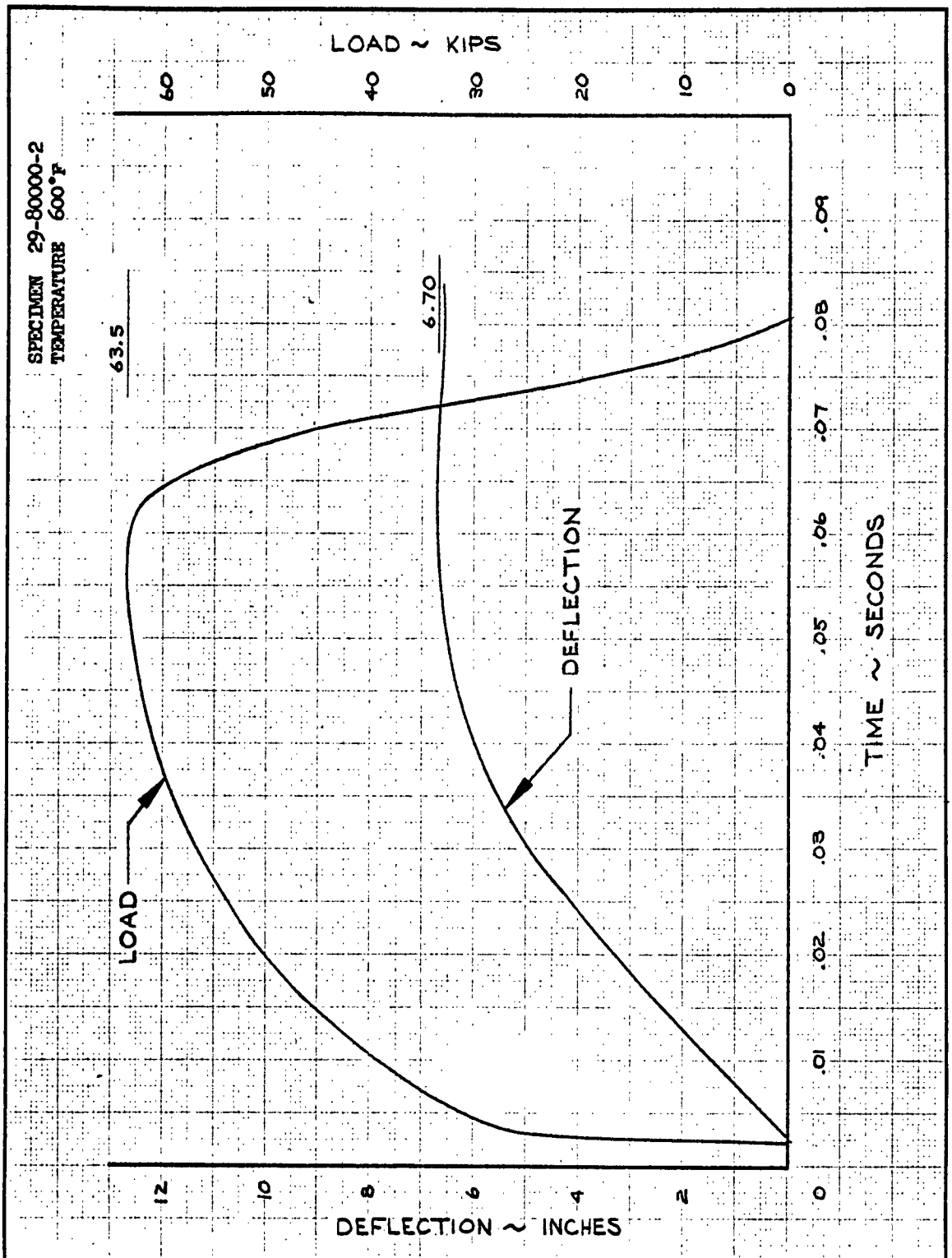
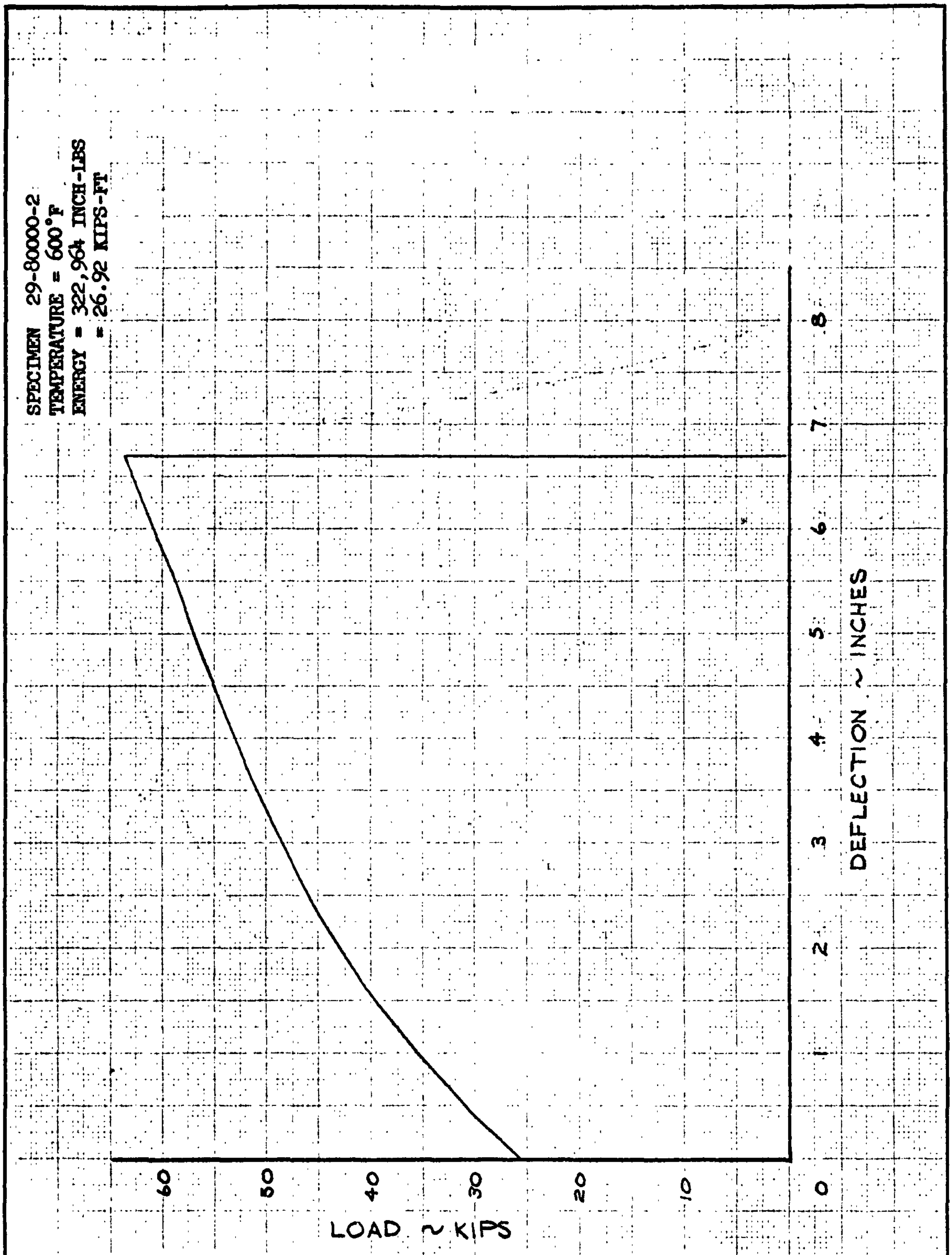


CALC	J.Lebo	1-15-[illegible]	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 9	X-20
CHECK	HKJ	1-18-[illegible]				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-30



CALC	J.Lebo	1-15-2	REVISED	DATE	X-20
CHECK	HKJ	1-18-2			
APR					LOAD VS DEFLECTION SPECIMEN NO. 9
APR					D2-80086
					THE BOEING COMPANY
					PAGE 3-31

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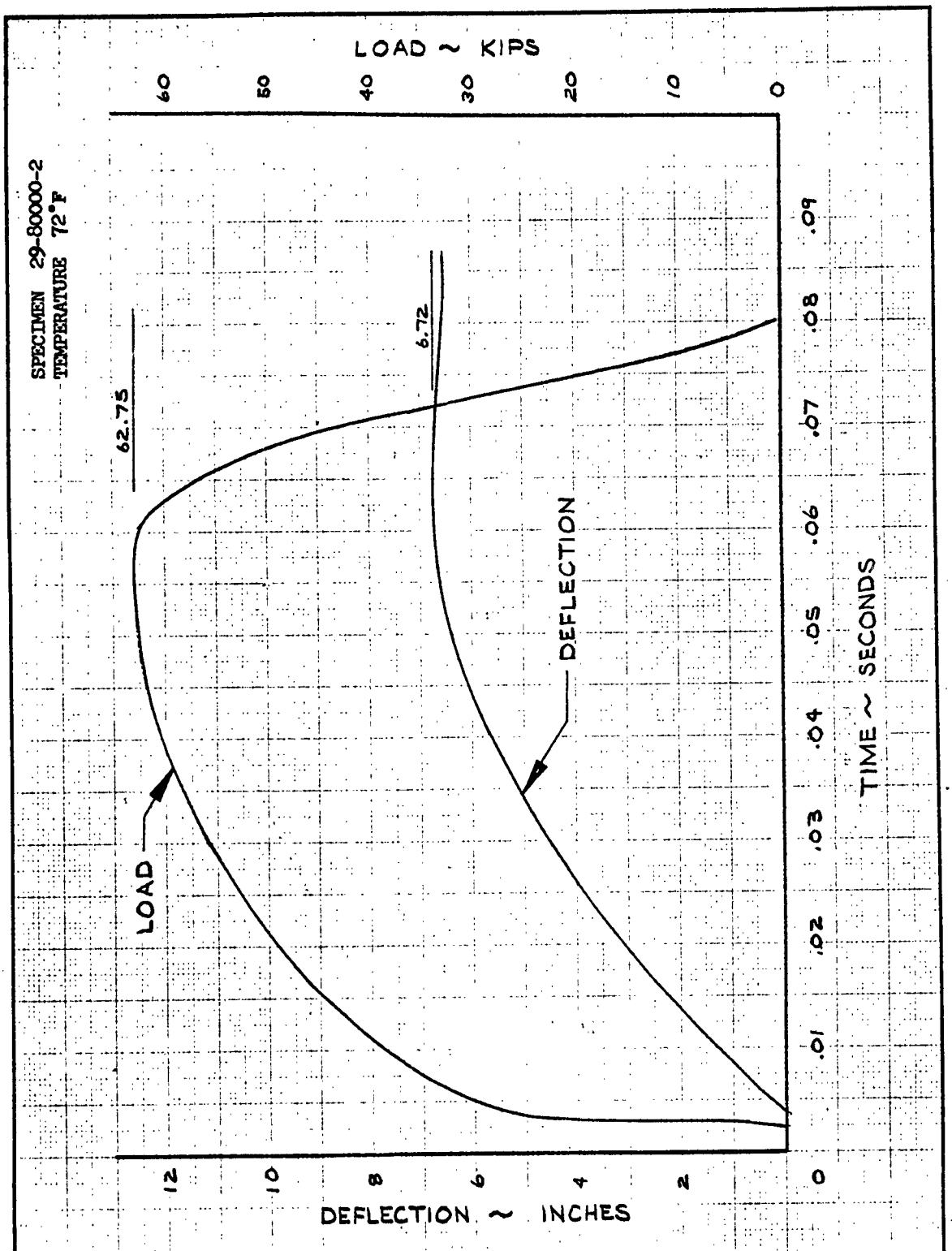

CALC	J.Lebo	1-16-2	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 10
CHECK	HKJ	1-18-2			
APR					
APR					THE BOEING COMPANY

X-20

D2-80086

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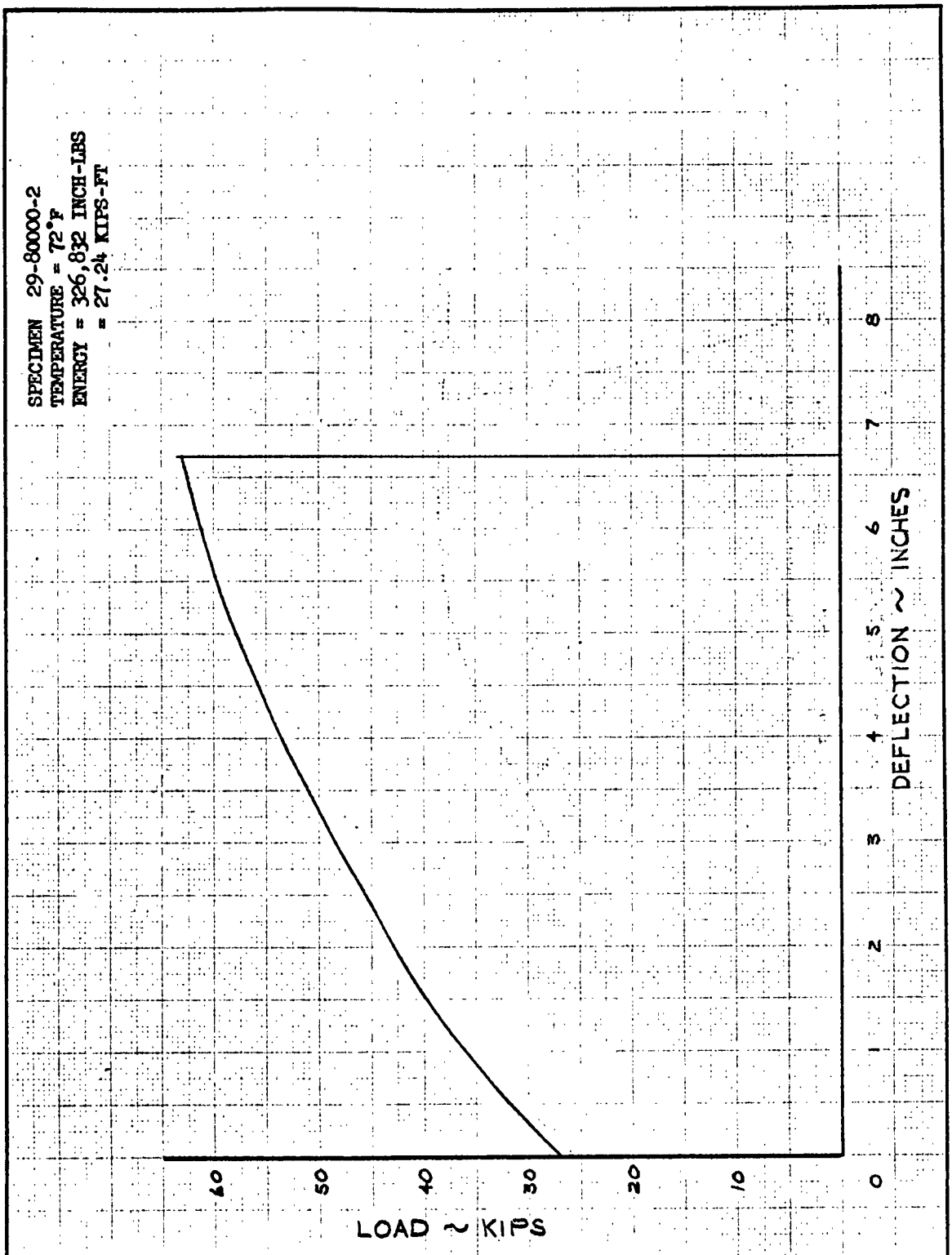

CALC	J.Lebo	1-17-2	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 10
CHECK	HKJ	1-18-2			
APR					
APR					THE BOEING COMPANY

X-20
D2-80086
PAGE 3-33

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US 4013 8000

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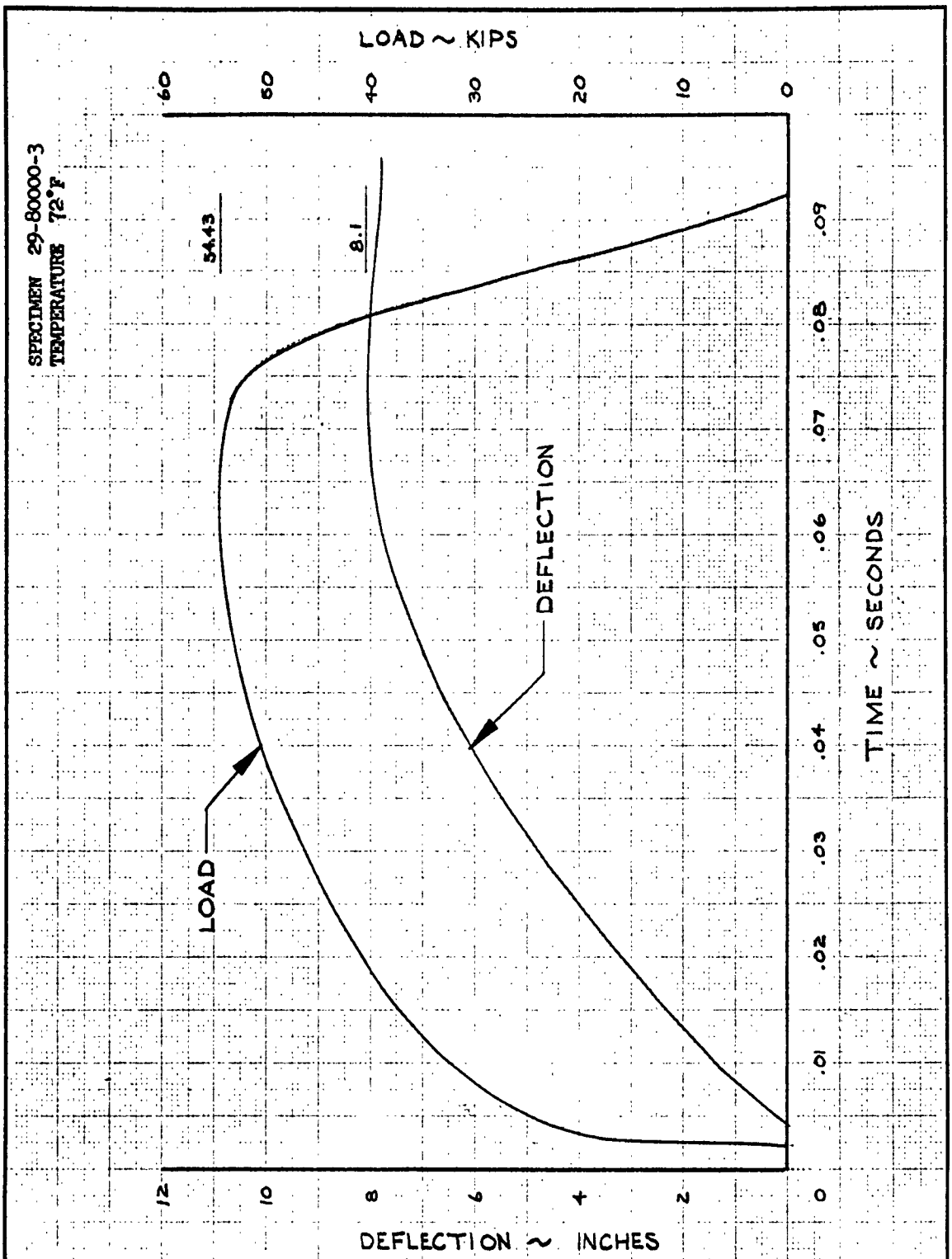
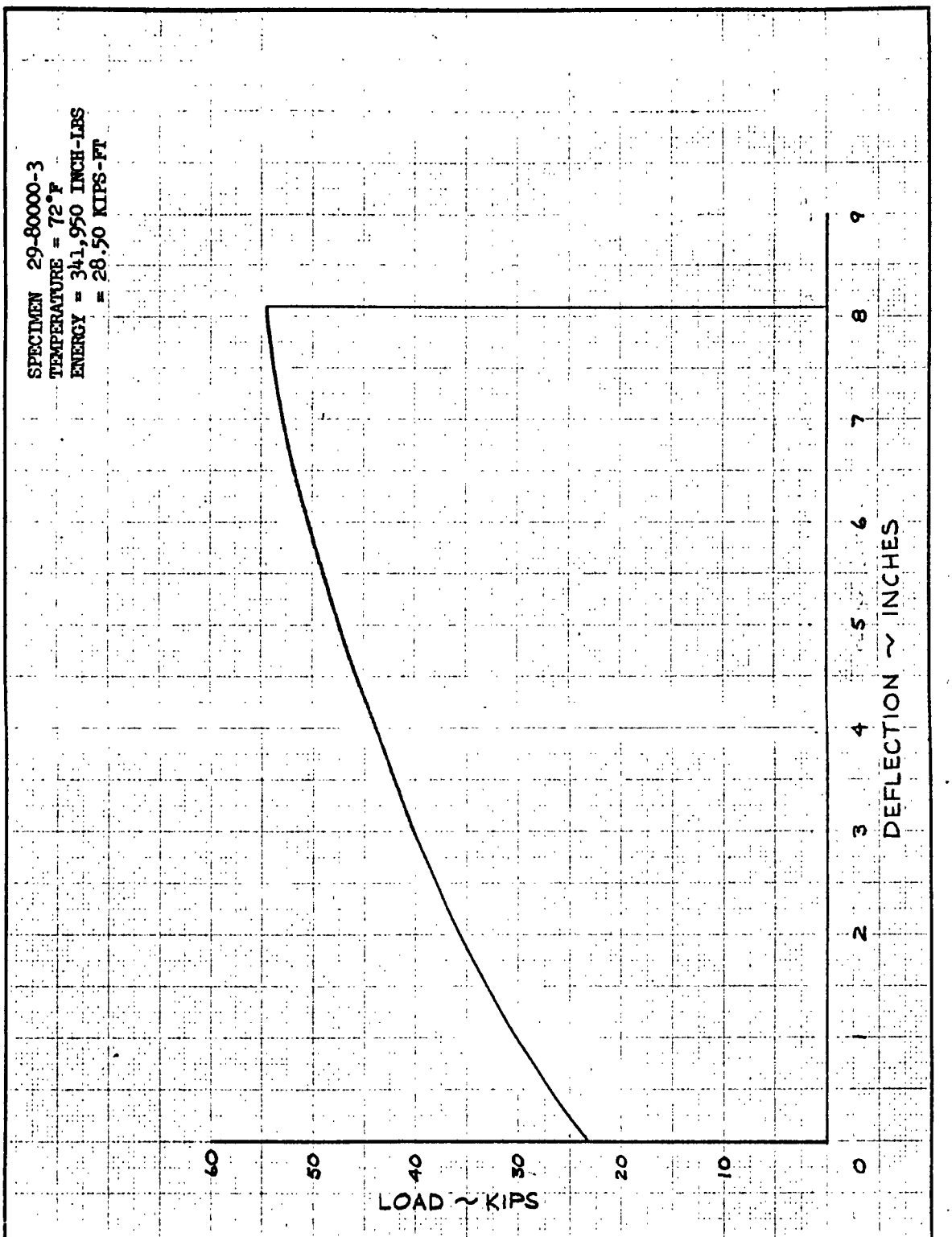
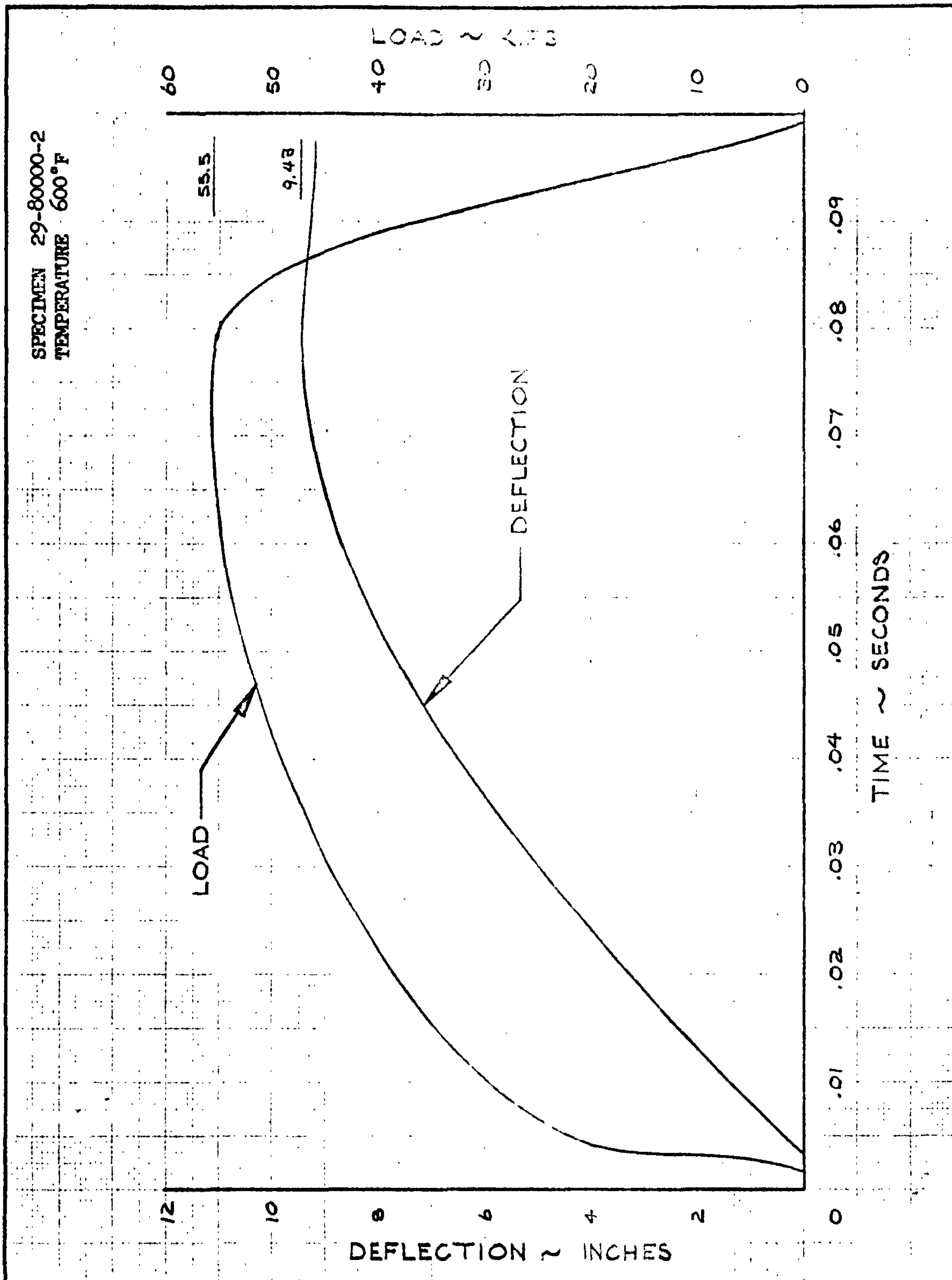


CALC	J.Lebo	1-17-2	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 11	X-20
CHECK	HKJ	1-18-2				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-34



CALC	J.Lebo	1-17-[illegible]	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 11
CHECK	HKJ	1-18-[illegible]			
APR					
APR					
					THE BOEING COMPANY

X-20
D2-80086
PAGE 3-35



CALC	J.Lebo	1-26-62	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 12	X-20
CHECK	Jorgensen	1-30-62				D2-80086
APR					THE BOEING COMPANY	PAGE 3-36
APR						

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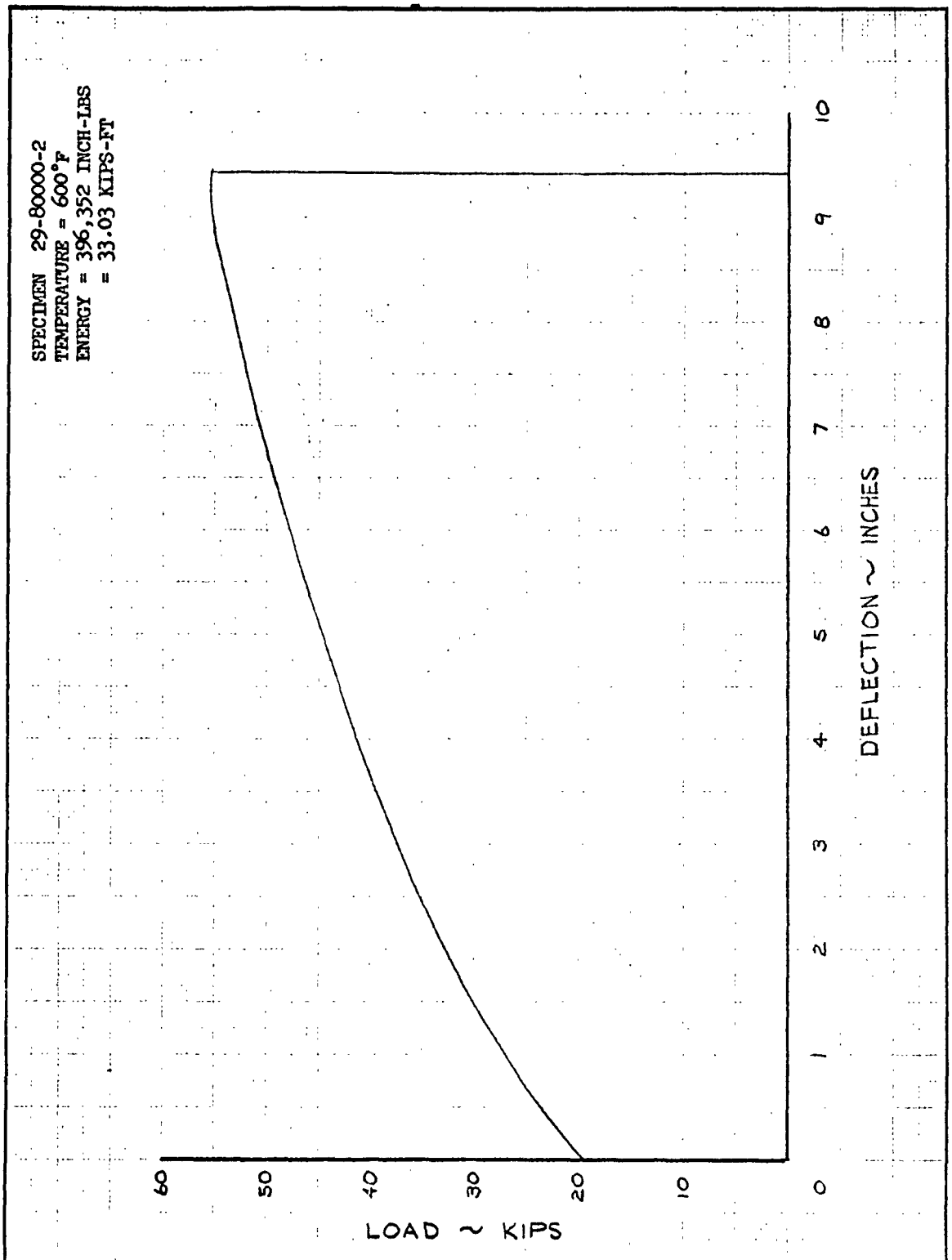
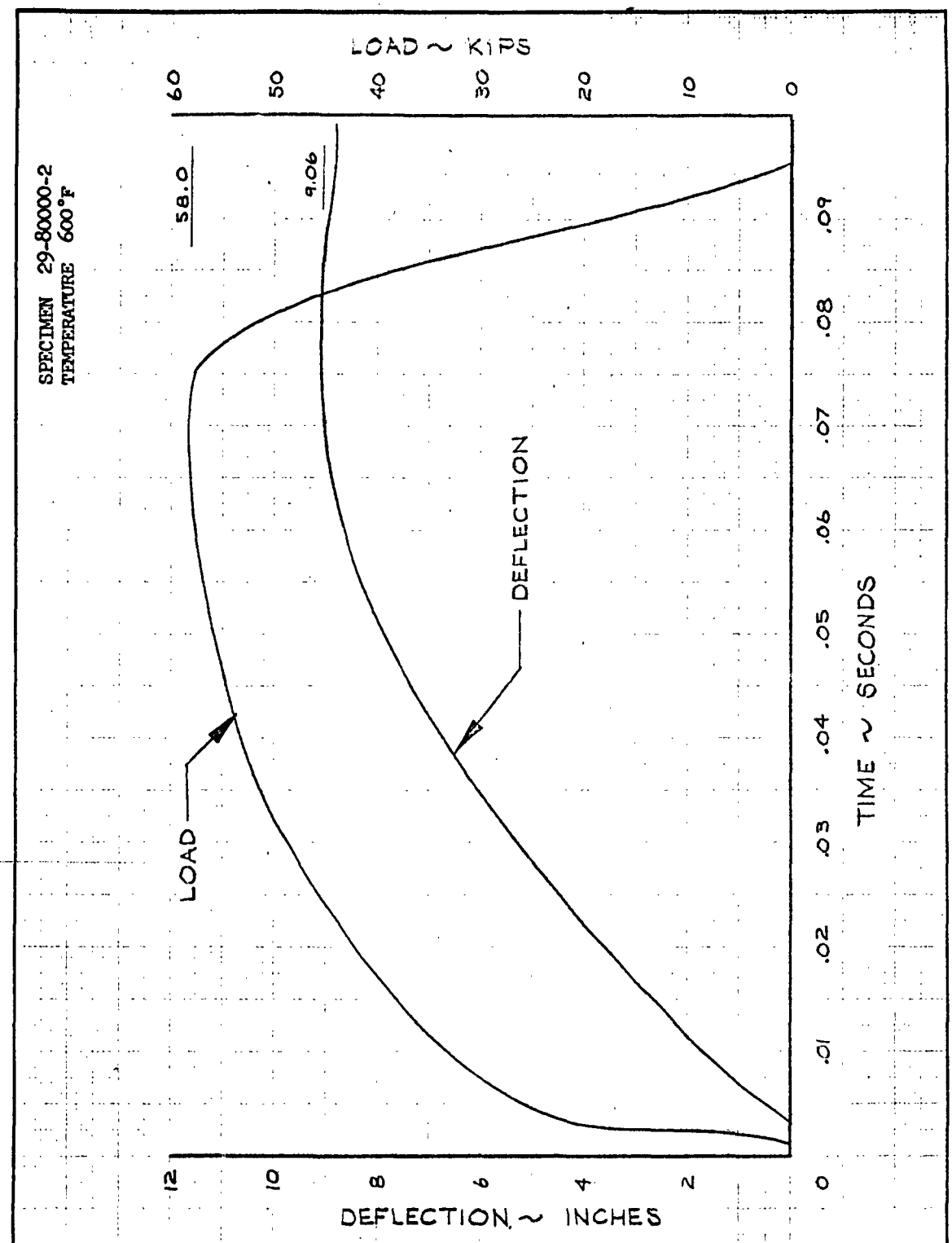


CALC	J.Lebo	1-26-62	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 12	X-20
CHECK	Jorgensen	1-30-62				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-37



CALC	J.Lebo	1-29-2	REVISED	DATE
CHECK	Jorgensen	1-30-2		
APR				
APR				

LOAD & DEFLECTION VS TIME
SPECIMEN NO. 13

X-20

D2-80086

THE BOEING COMPANY

PAGE 3-38

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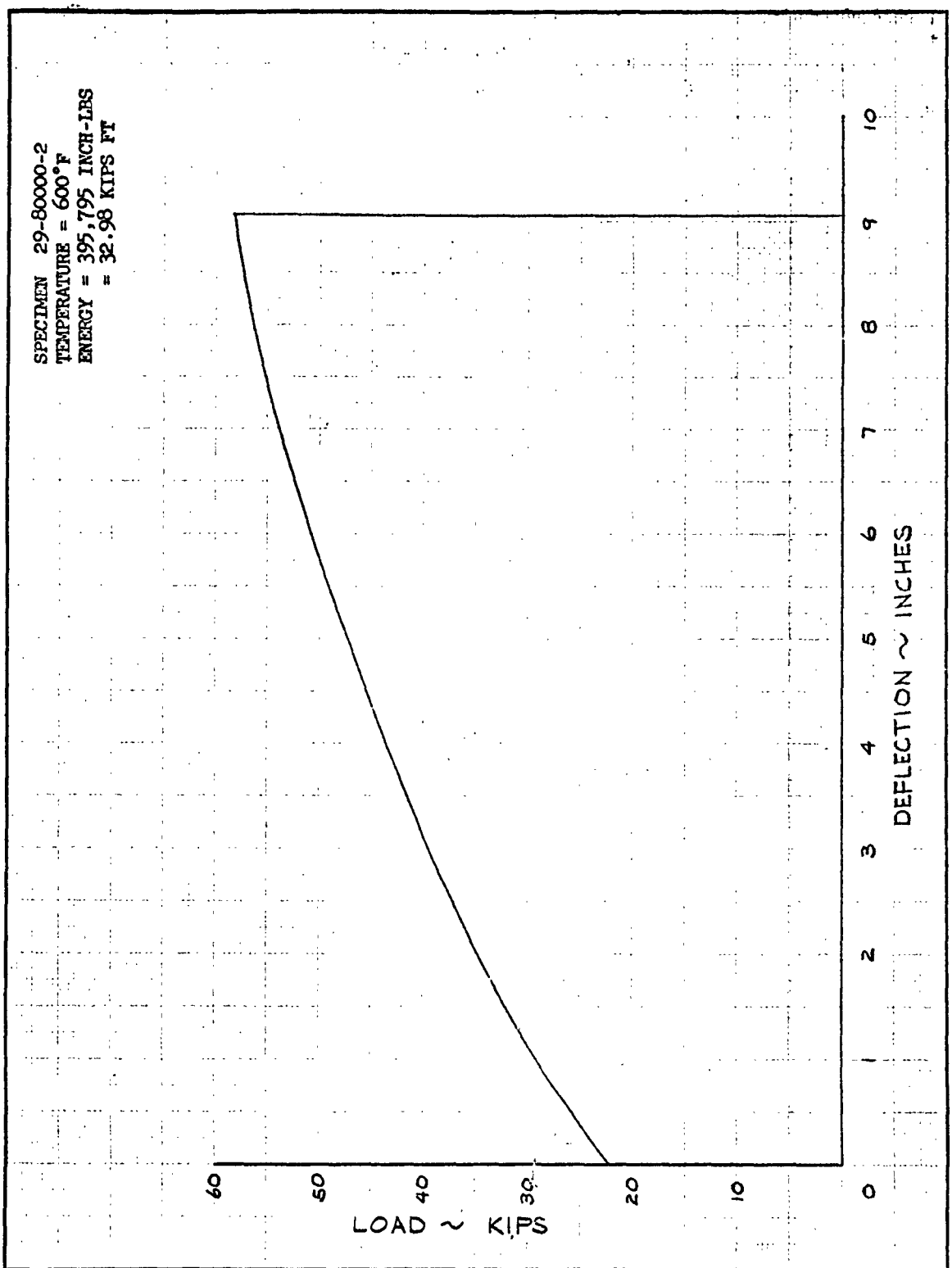

CALC	T.Lebo	1-29-2	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 13
CHECK	Jorgensen	1-30-2			
APR					
APR					
					THE BOEING COMPANY

X-20
D2-80086
PAGE 2-39

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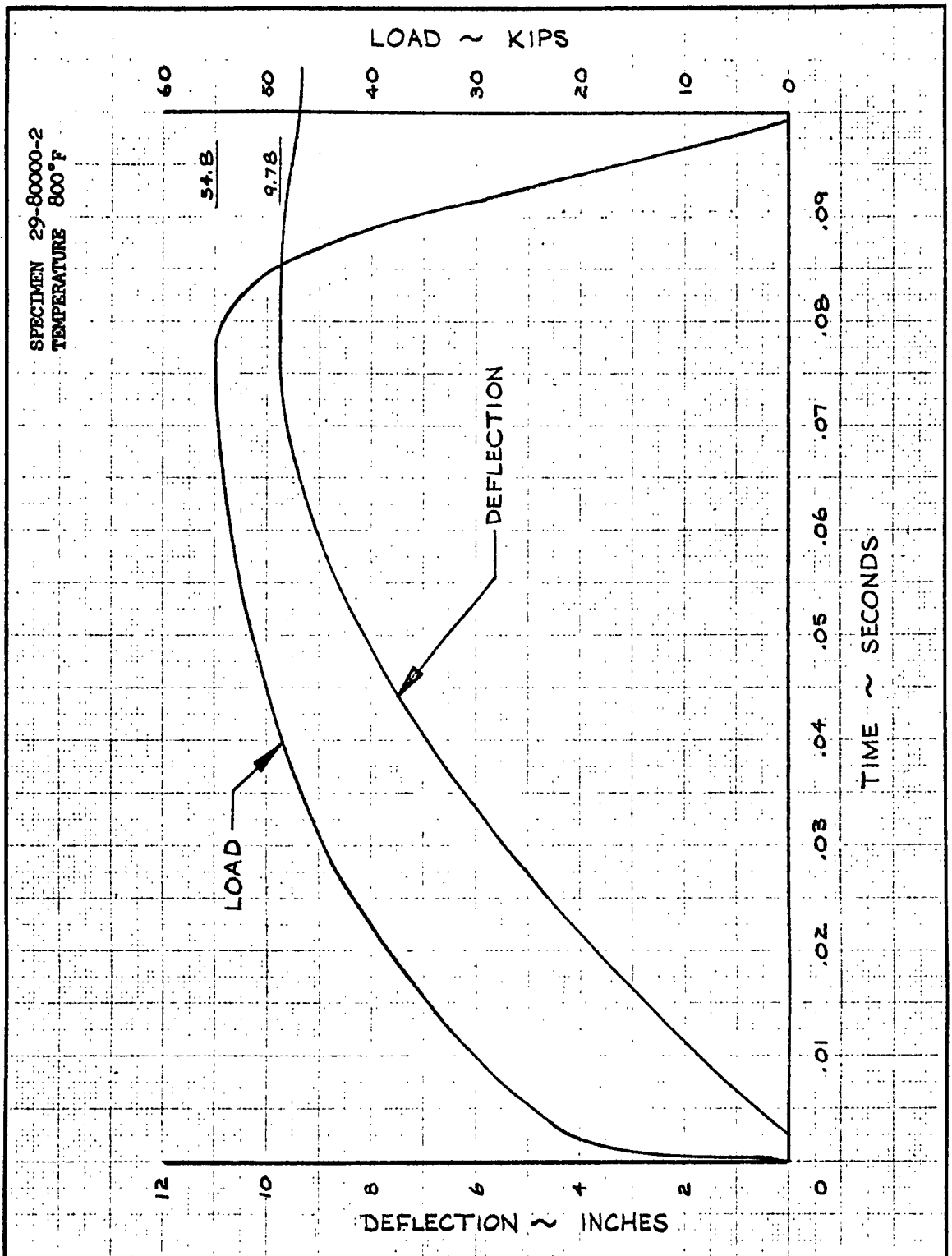

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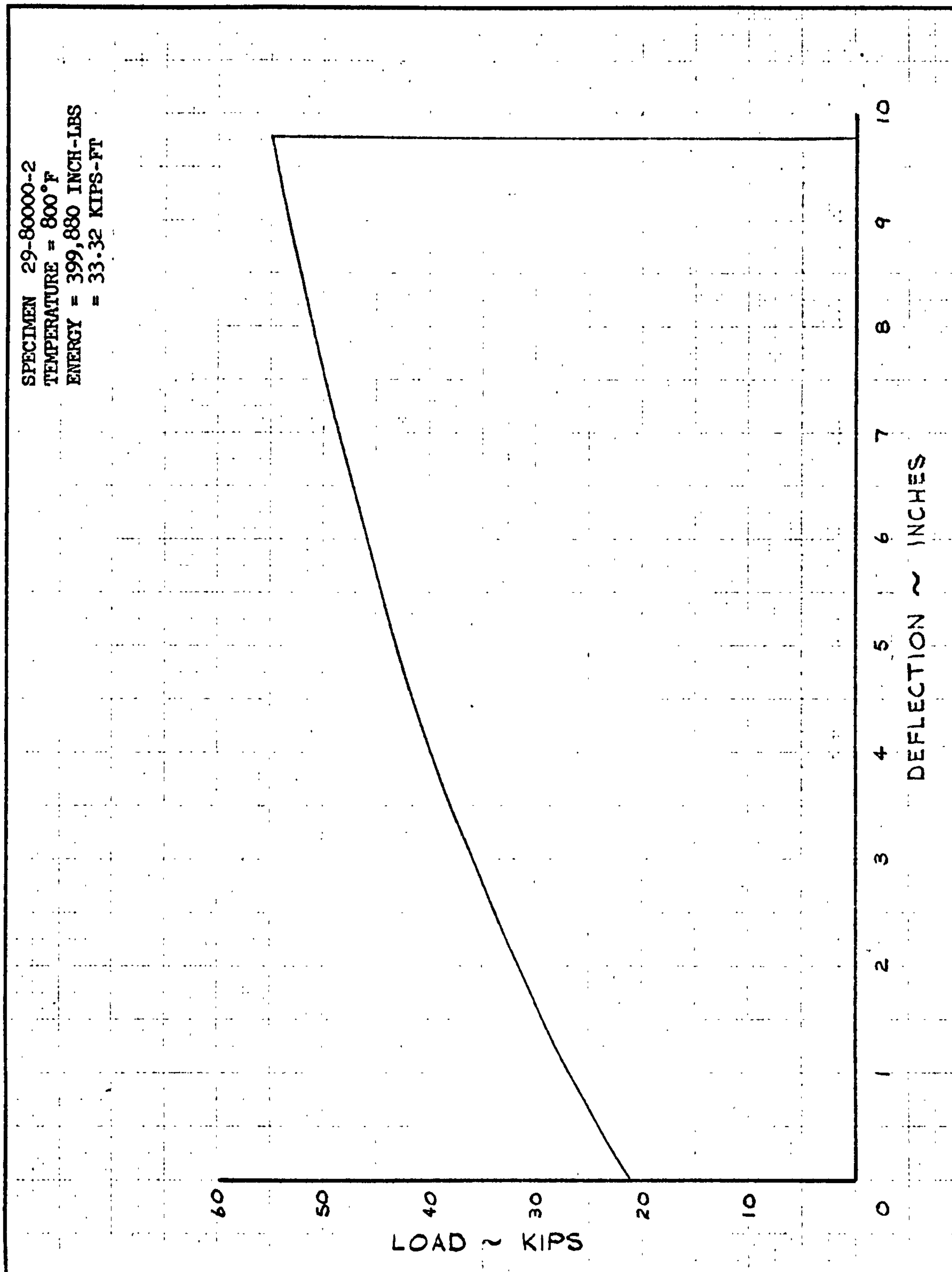
CHECK	Jorgensen	2-8-2			
APR					
APR					
					THE BOEING COMPANY

X-20

D2-80086

PAGE 3-40



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CHECK	Jorgensen	2-8-2				D2-80086
APR					THE BOEING COMPANY	PAGE 3-41
APR						

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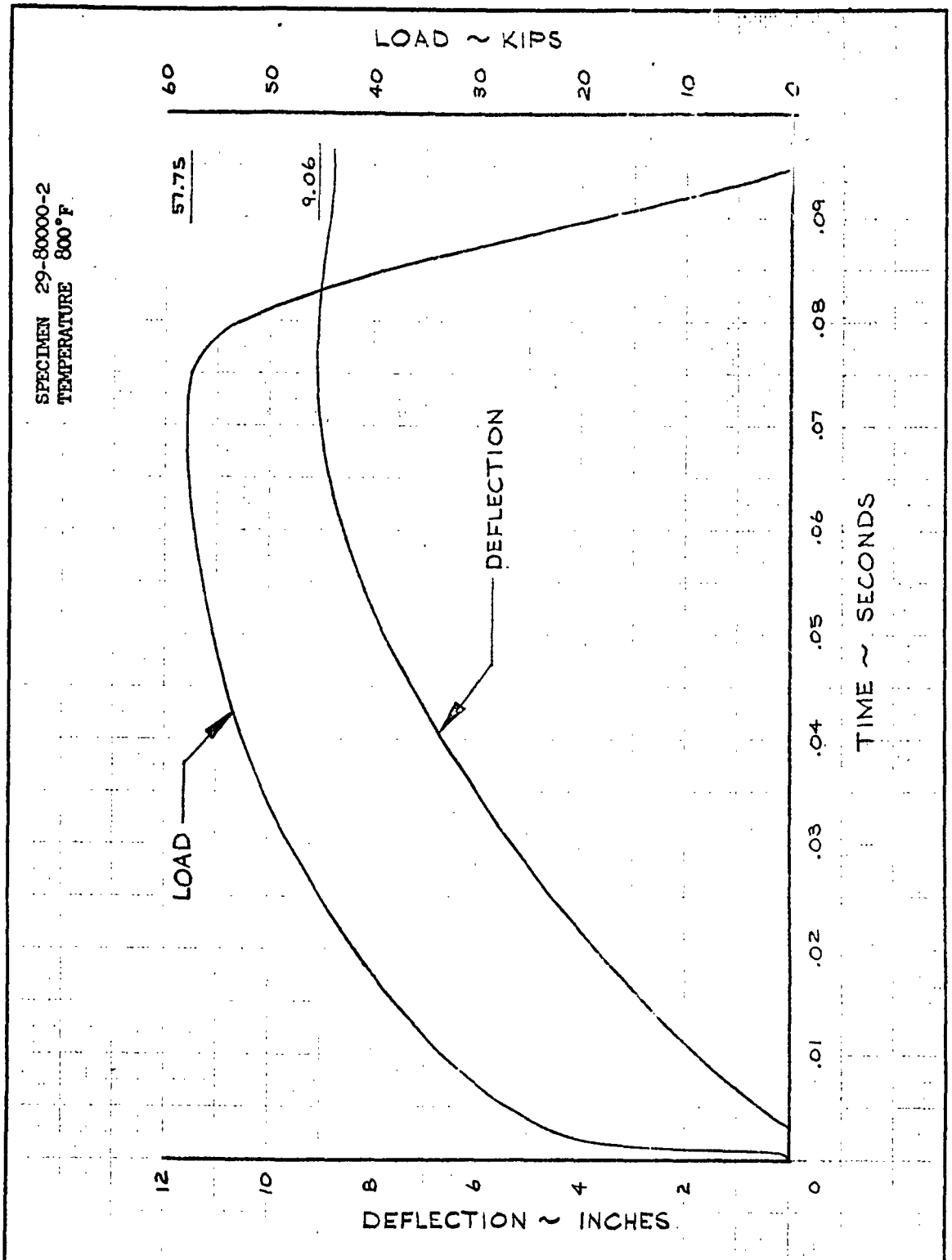

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CHECK	Jorgensen	2-8-2				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-42

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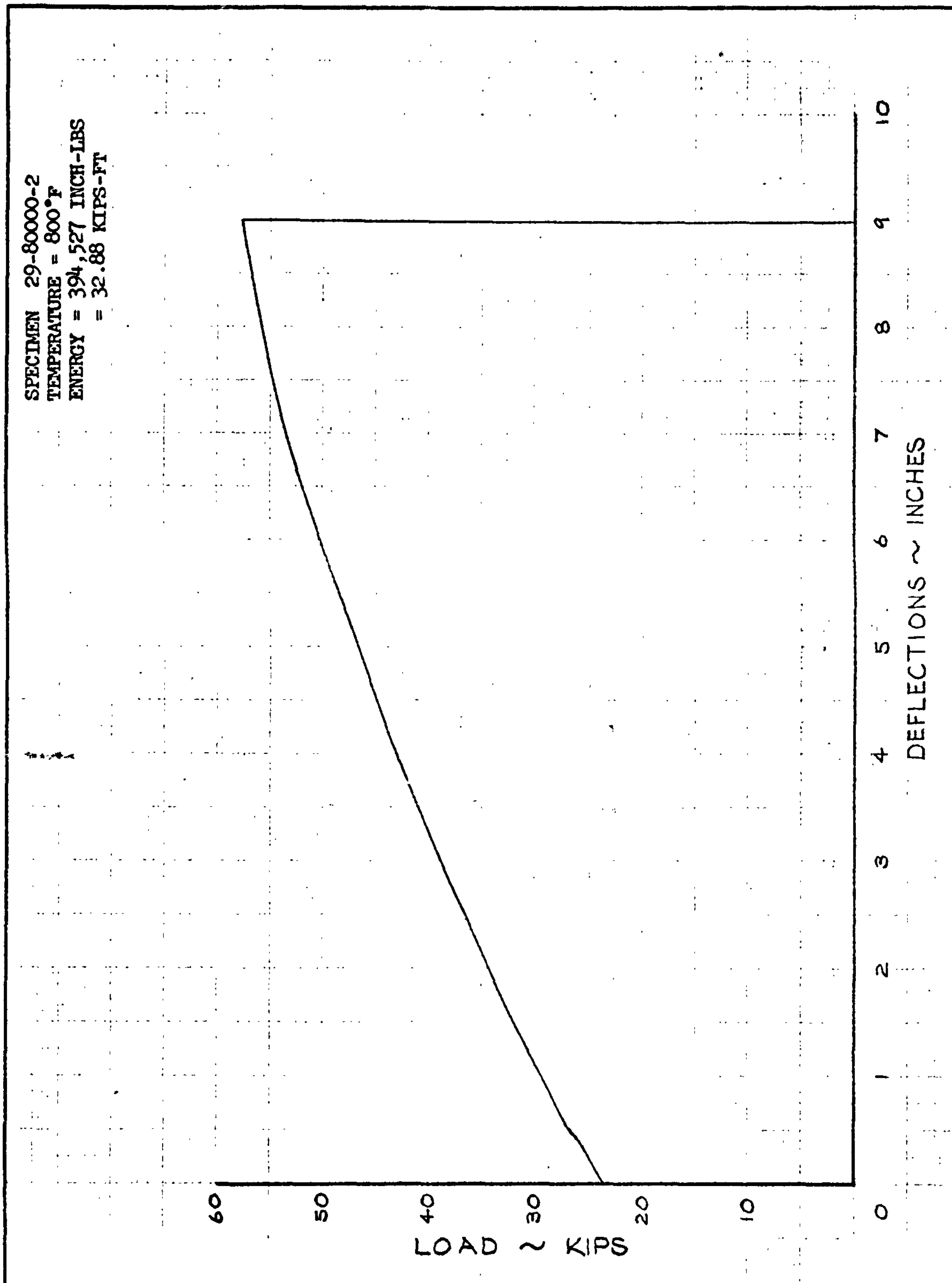

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CHECK	Jorgensen	2-8-2				D2-80086
APR					THE BOEING COMPANY	PAGE 3-43
APR						

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ALBANENE® 70317

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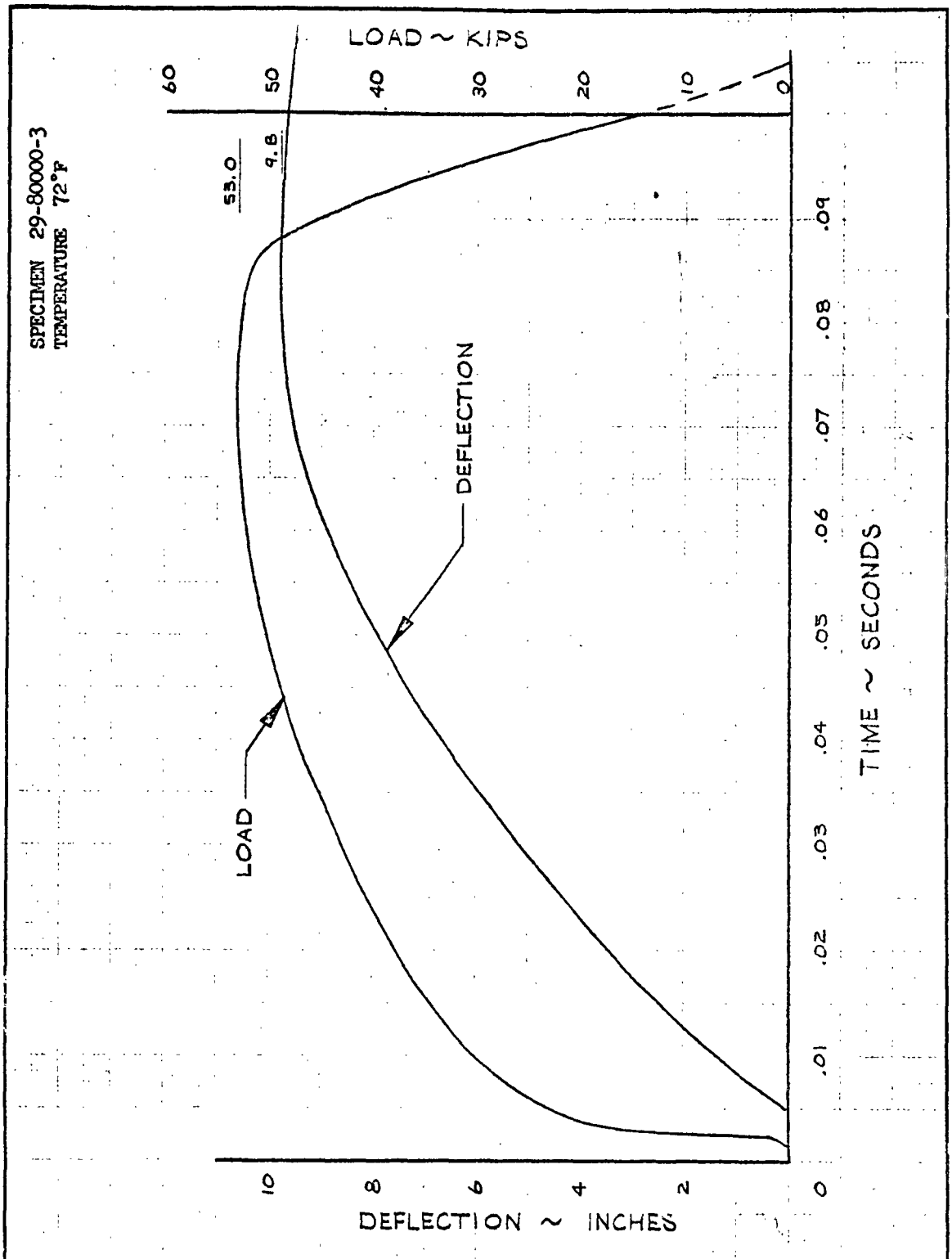

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CHECK						D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-44

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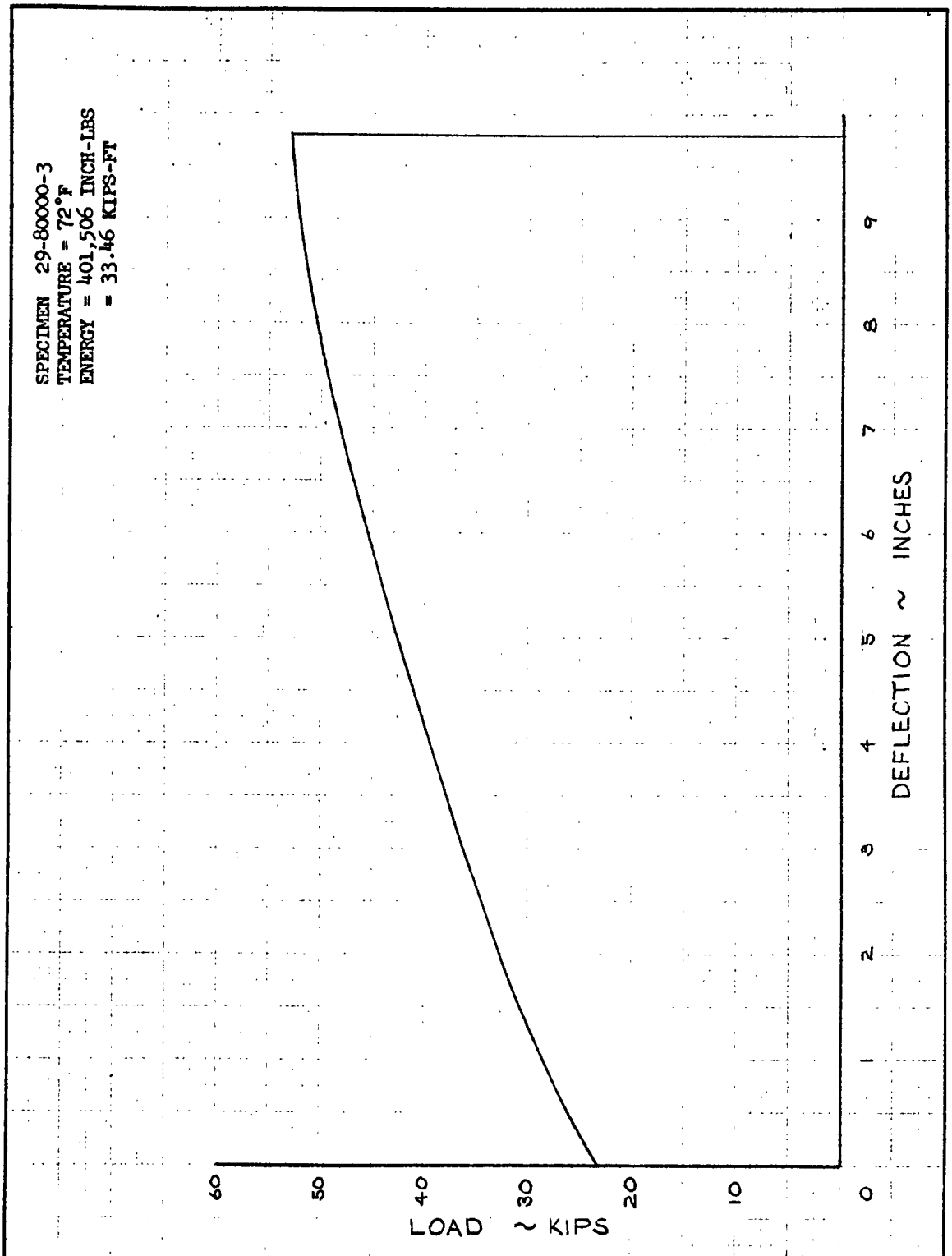

CALC	J. Lebo	2-8-2	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 16	X-20
CHECK						D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-45

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US 4918 8000

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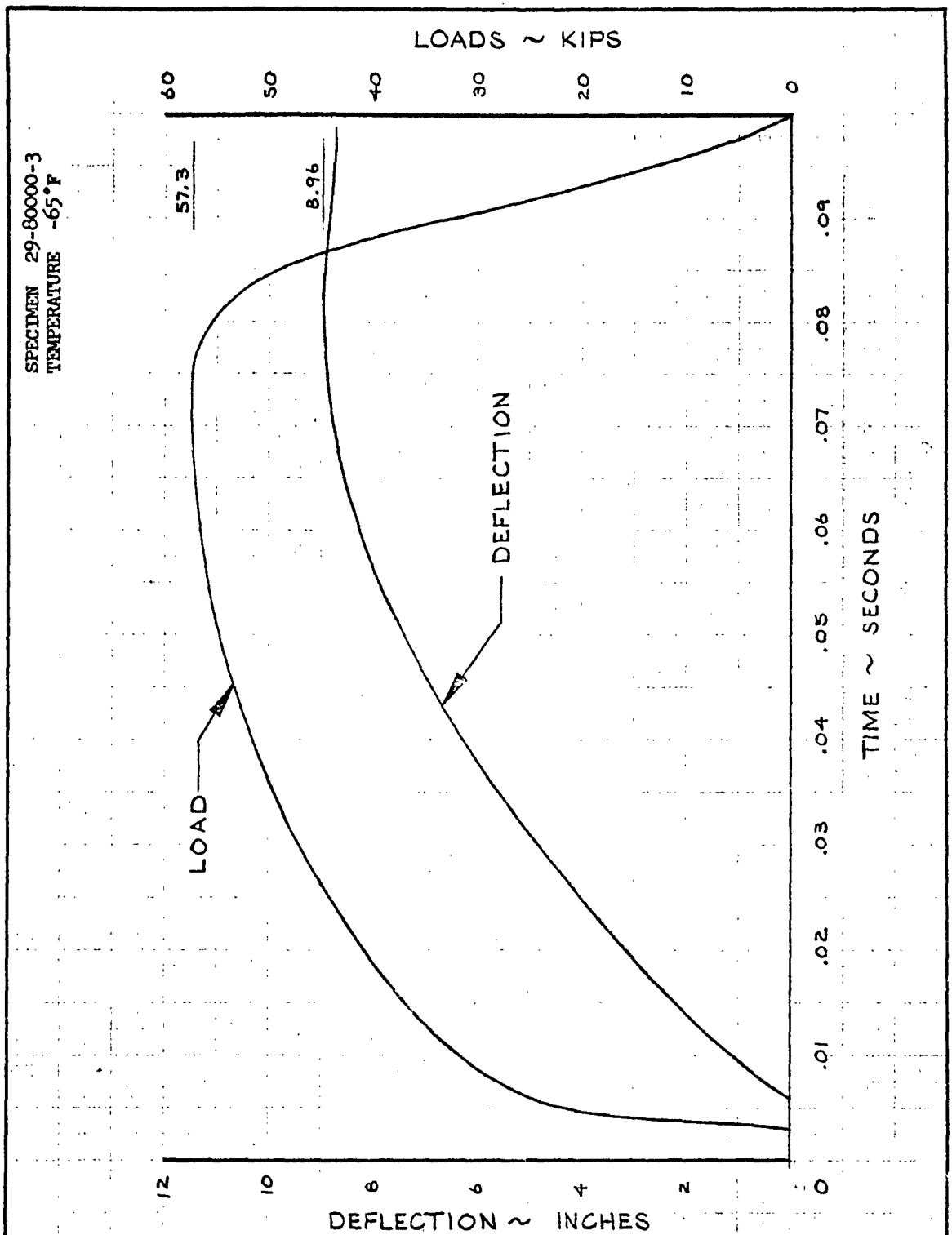
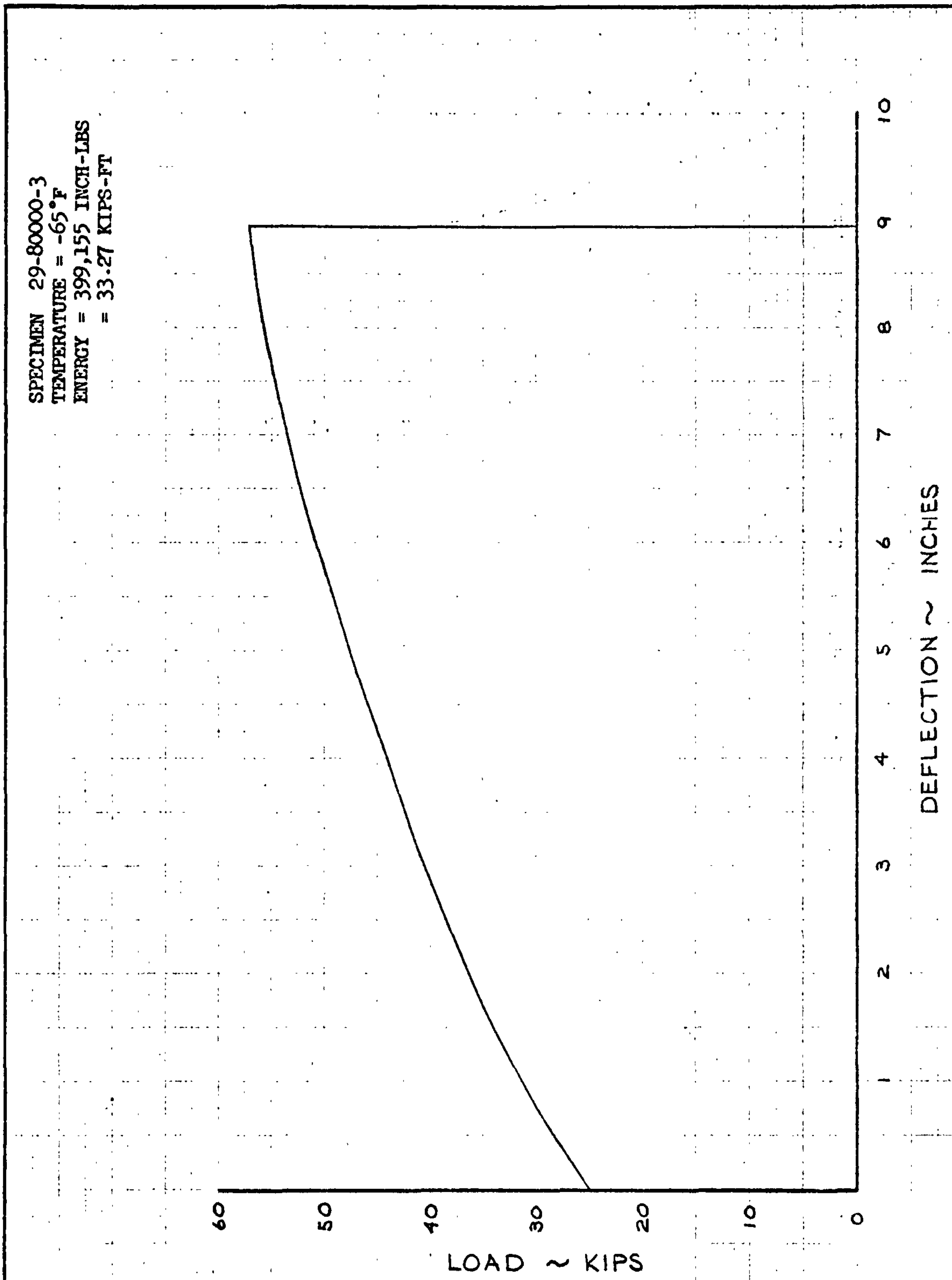


CALC	J.Lebo	2-19-2	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 17	X-20
CHECK	Jorgensen	2-20-2				D2-80086
APR						
APR					THE BOEING COMPANY	PAGE 3-46



			REVISED	DATE		
CALC	J.Lebo	2-19-2			LOAD VS DEFLECTION SPECIMEN NO. 17	X-20
CHECK	Jorgensen	2-20-2				D2-80086
APR					THE BOEING COMPANY	PAGE
APR						3-47

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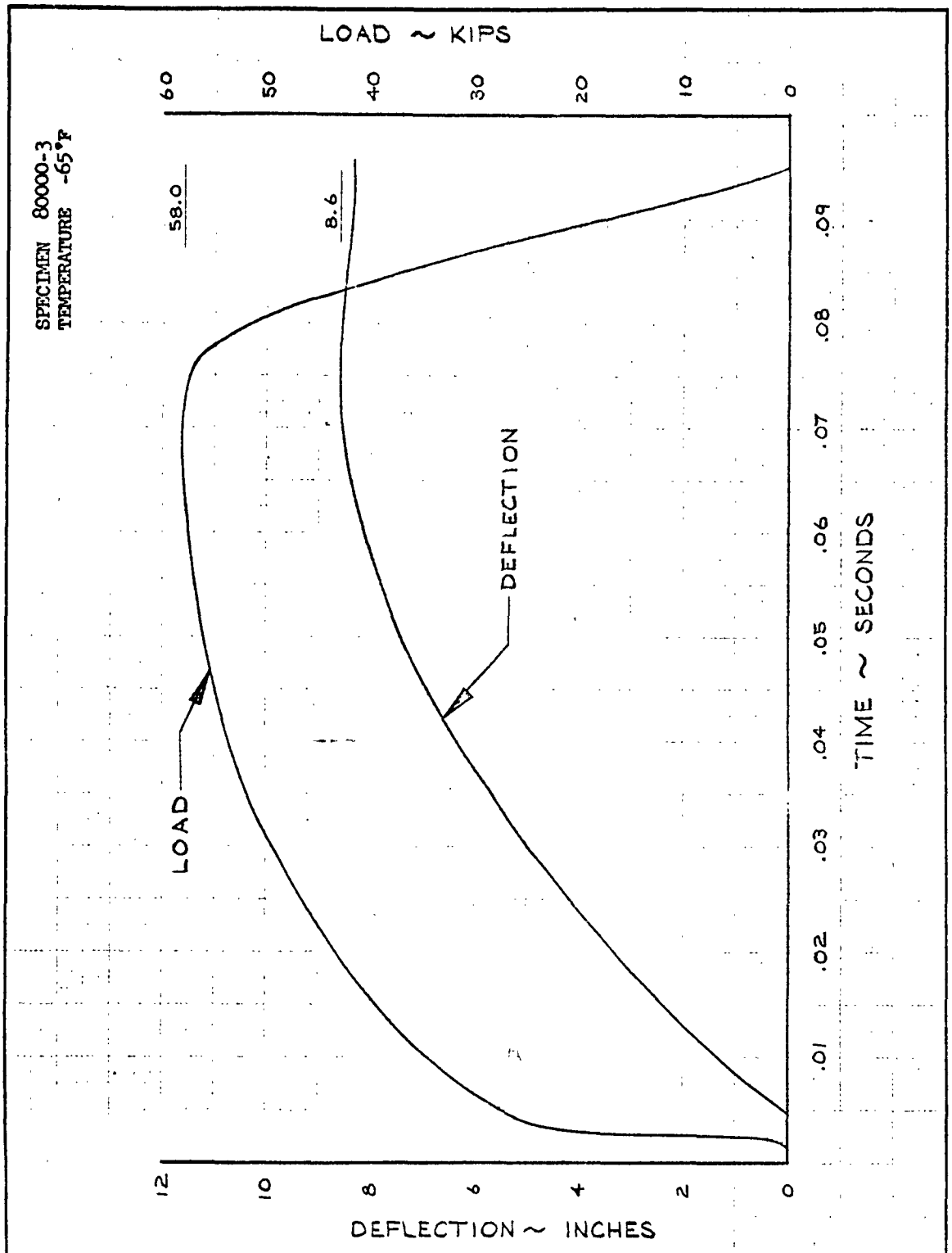
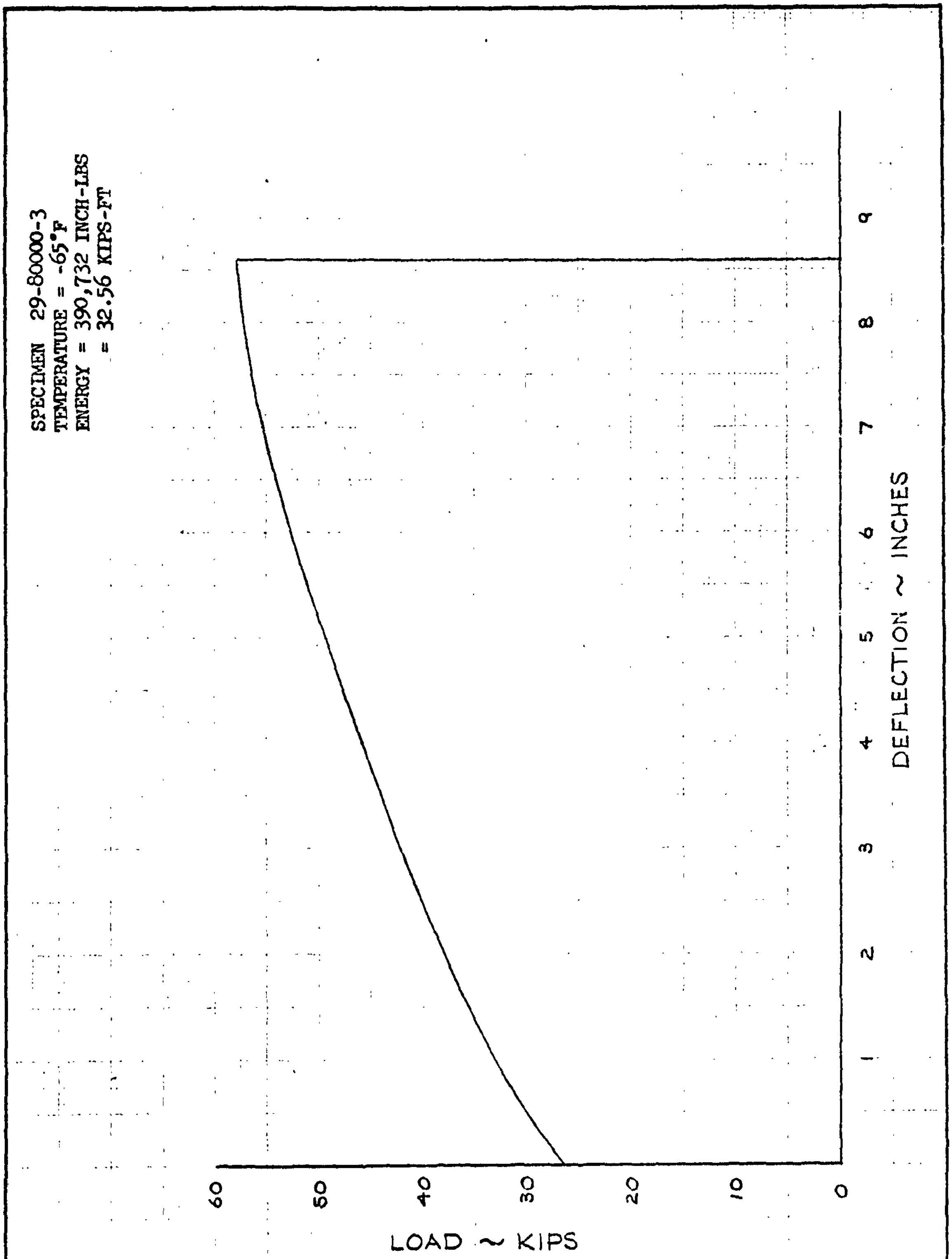


CALC	J.Lebo	2-21-?	REVISED	DATE	LOAD & DEFLECTION VS TIME SPECIMEN NO. 18
CHECK	Jorgensen	2-21-?			X-20
APR					D2-80086
APR					THE BOEING COMPANY
					PAGE 3-48



CALC	J.Lebo	2-21-2	REVISED	DATE	LOAD VS DEFLECTION SPECIMEN NO. 18
CHECK	Jorgensen	2-21-2			X-20
APR					D2-80086
APR					THE BOEING COMPANY
					PAGE 3-49

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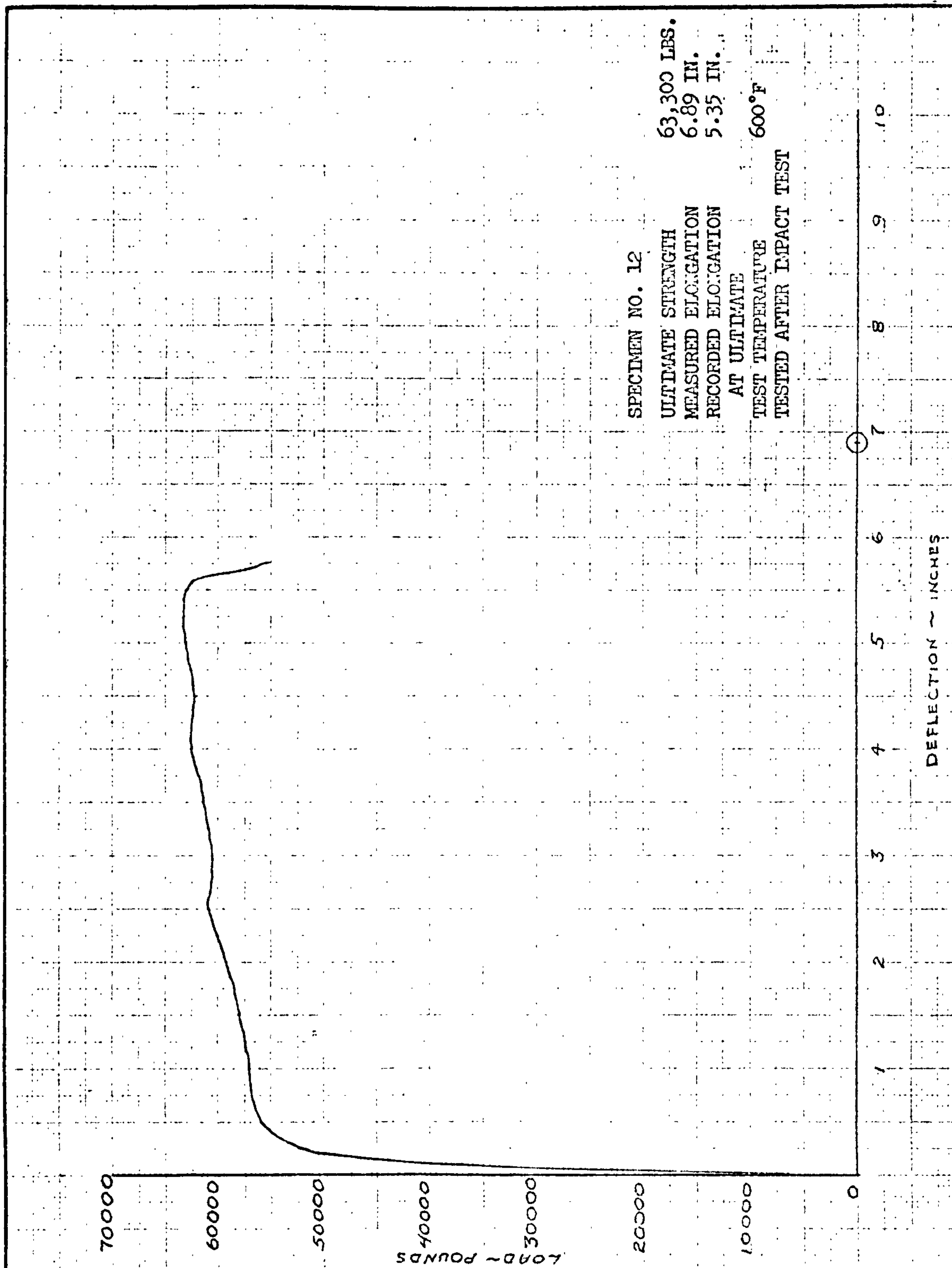
UA 4013 8000

K+E ALBANENE® 70317



CALC	L WESS	7-23-2	REVISED	DATE
CHECK	McDANIEL	7-27-62		
APR				
APR				

STATIC LOADING
LOAD vs DEFLECTION
D.S. LANDING GEAR ENERGY STRAP

BOEING AIRPLANE COMPANY

X-20

D2-80026

PAGE 3-50

BAC 461 C-R4

K+E ALBANENE 1961 TRACING PAPER 60029

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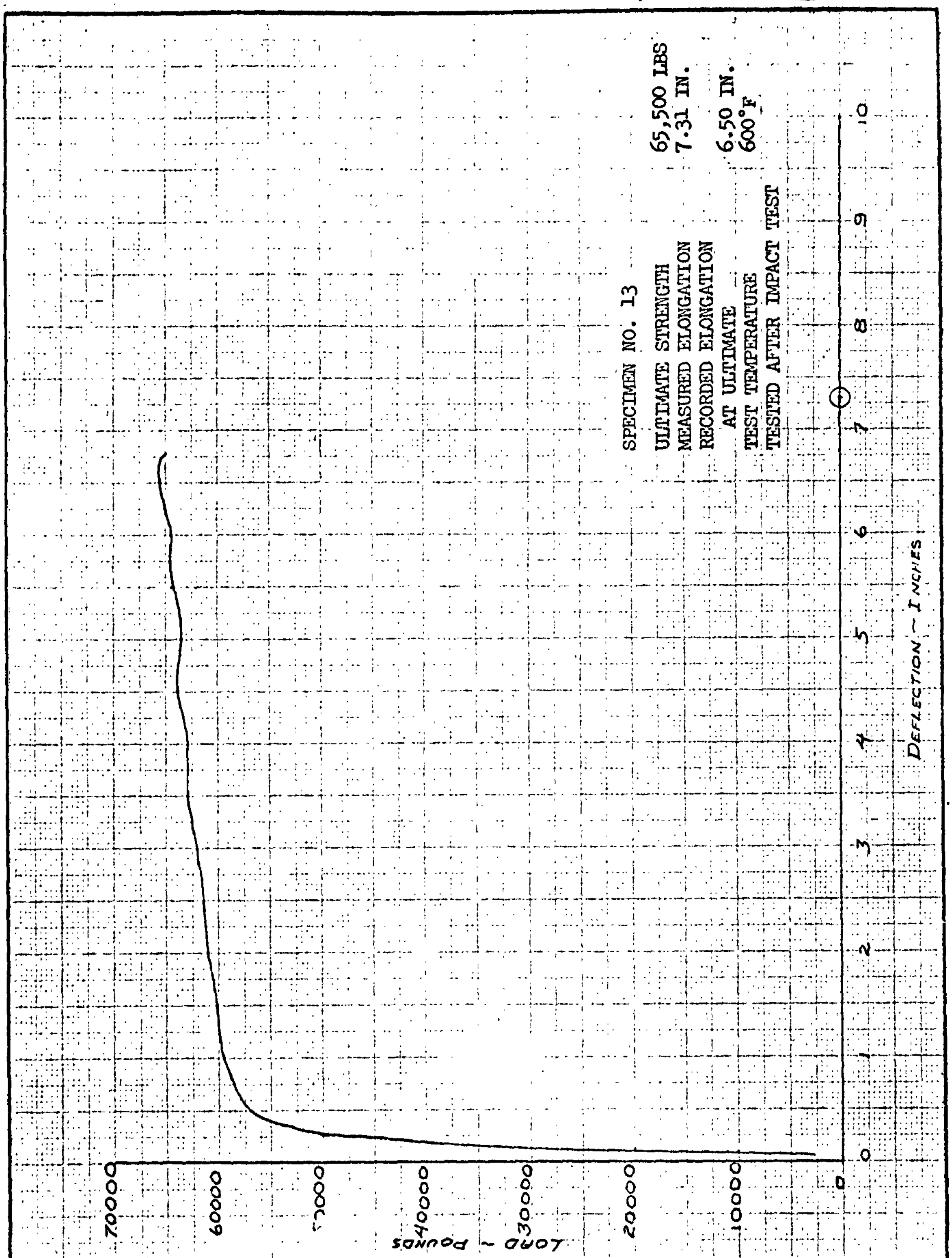

CALC	L. WESS	7-23-62	REVISED	DATE	STATIC LOADING LOAD vs. DEFLECTION D.S. LANDING GEAR ENERGY STRAP	X-20
CHECK	McDANIEL	7-27-62				D2-80080
APR					BOEING AIRPLANE COMPANY	PAGE 3-51
APR						

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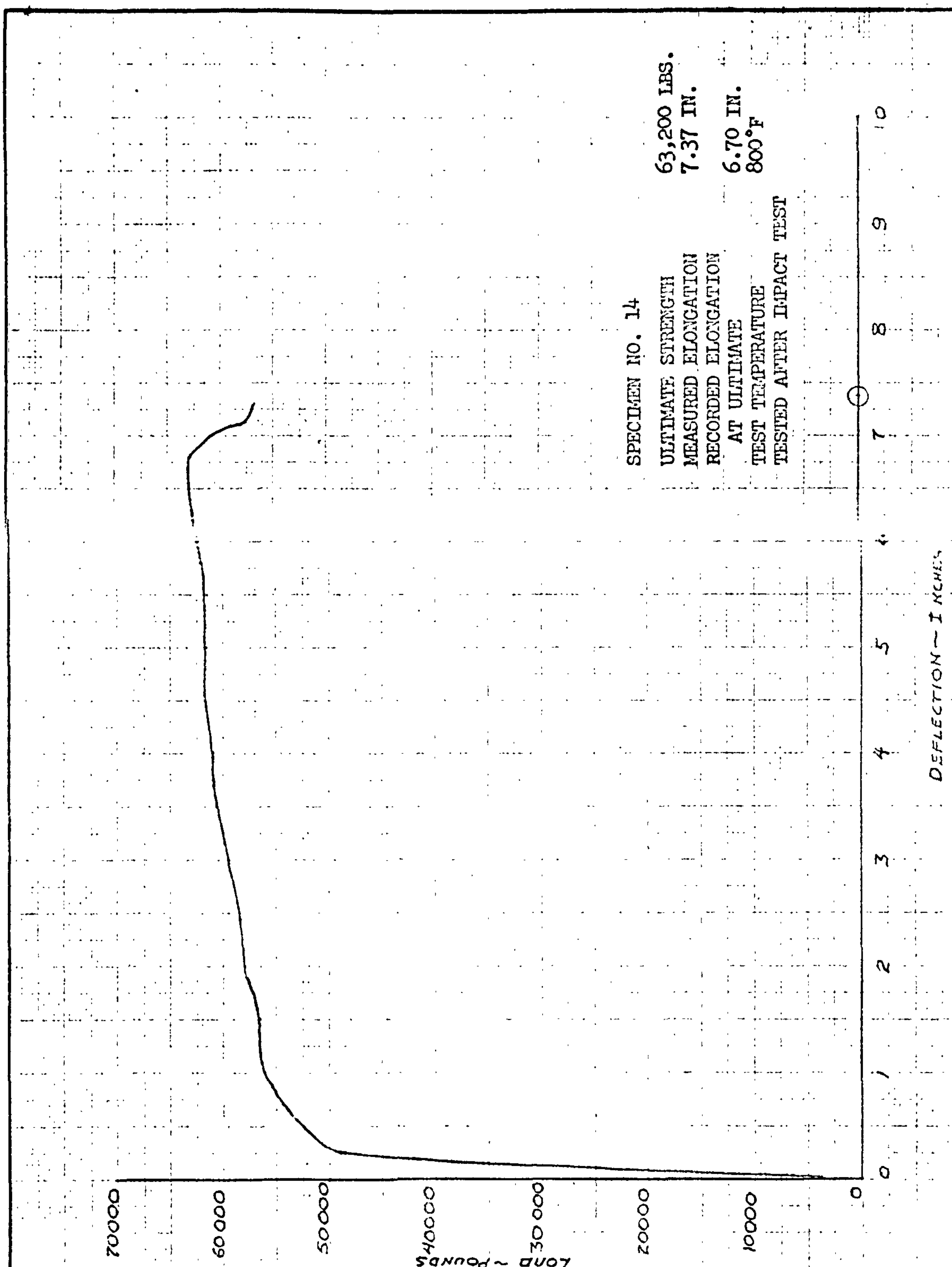
BAC 661 C-R4 K+E ALBANENE 196L 60629



CALC	L. WESS	7-23-2	REVISED	DATE
CHECK	McDANIEL	7-27-6		
APR				
APR				

STATIC LOADING
LOAD VS DEFLECTION
D.S. LANDING GEAR ENERGY STRAP

BOEING AIRPLANE COMPANY

X-20

D2-80

PAGE 3-

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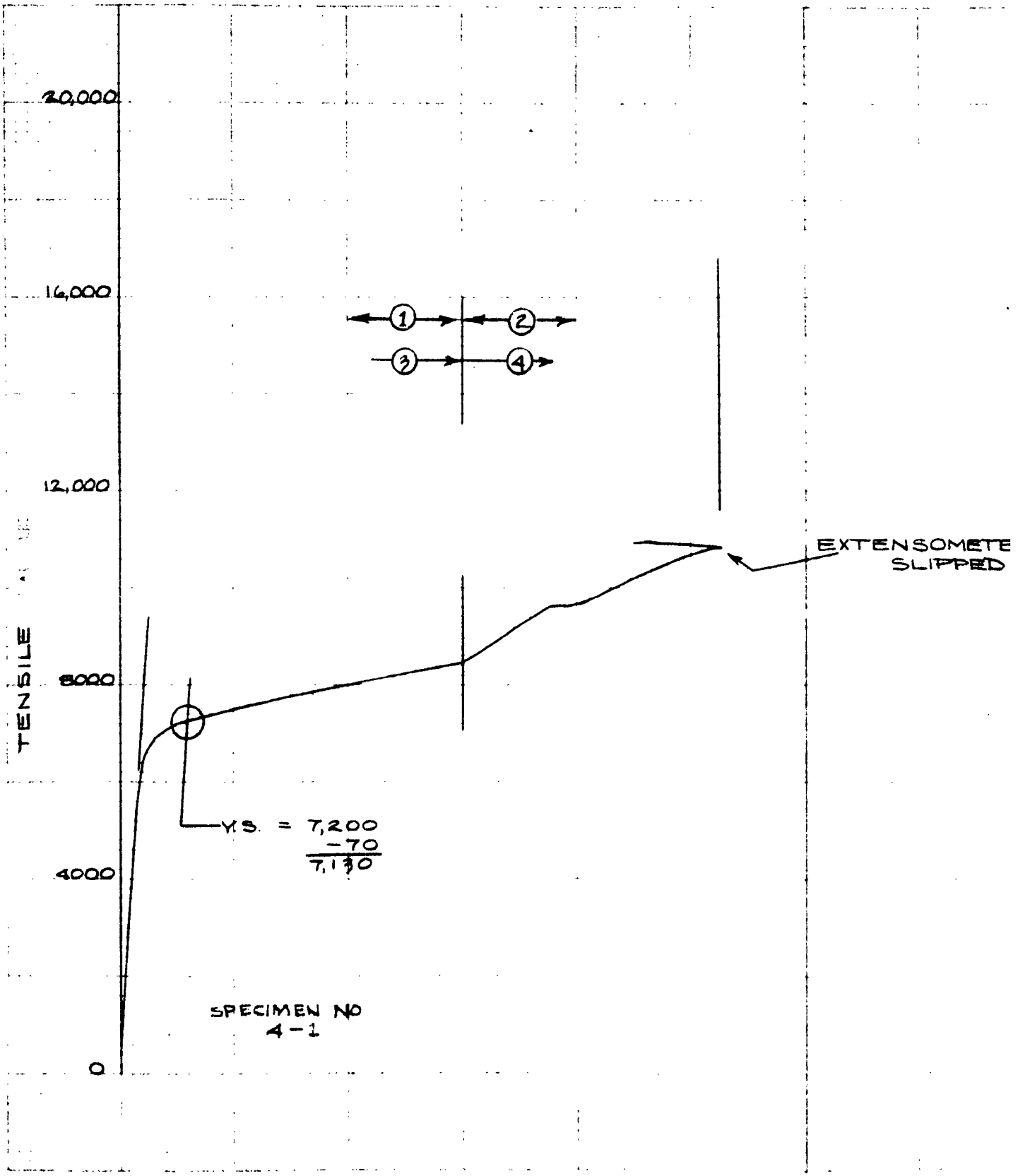
BAC 461 C-R4

K-E ALBANENE TRACING PAPER


20,000
16,000
12,000
8000
4000
0
TENSILE
EXTENSOMETE
SLIPPED
Y.S. = 7,200
-70
7,130
SPECIMEN NO
4-1

EXTENSOMETER GRIP SLIPPED

2

① .005 ② .005

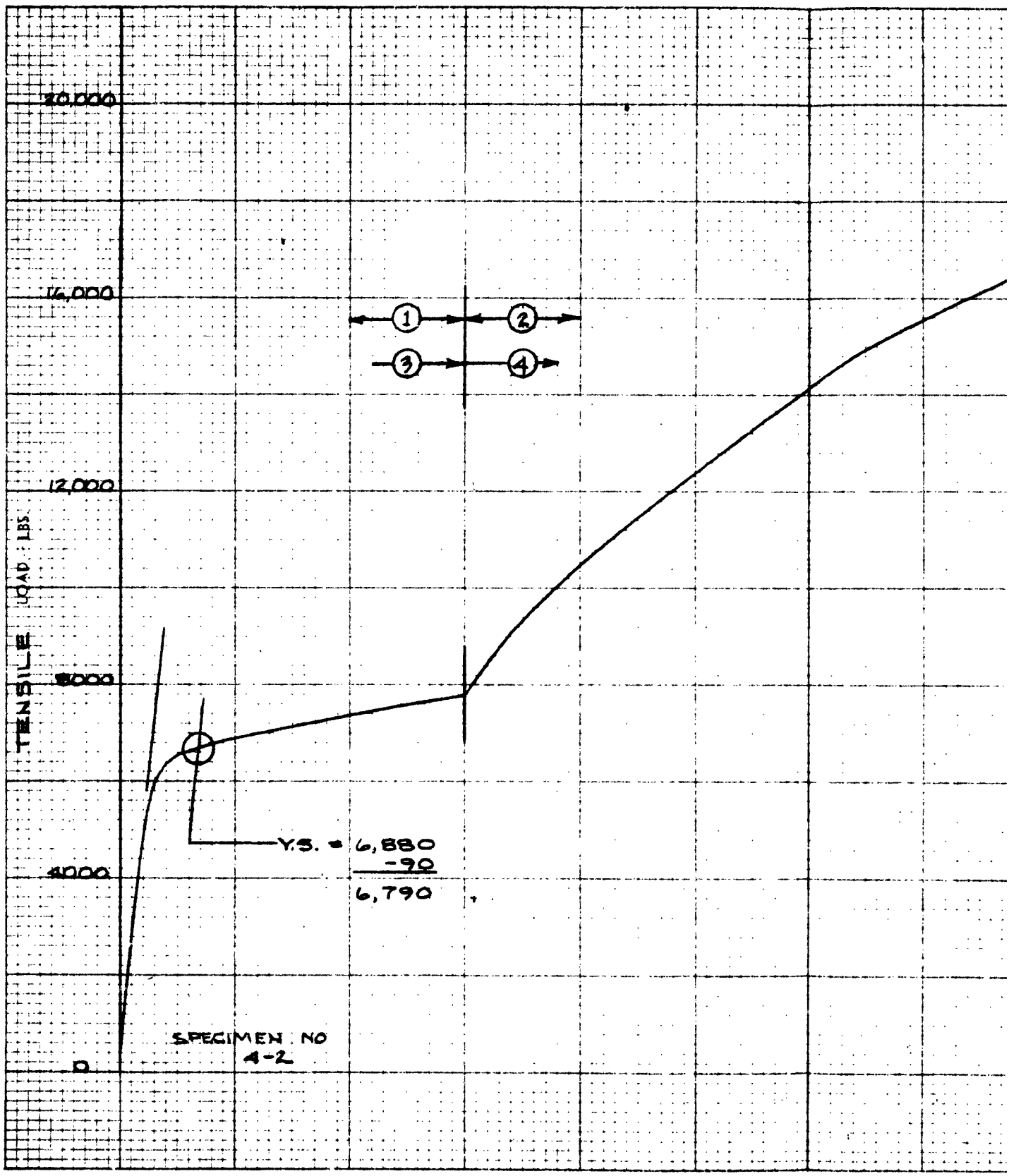
③ .020 ④ 0.10

CALC ELS 4/30/2 OPR _____

CHECK _____ APPD _____

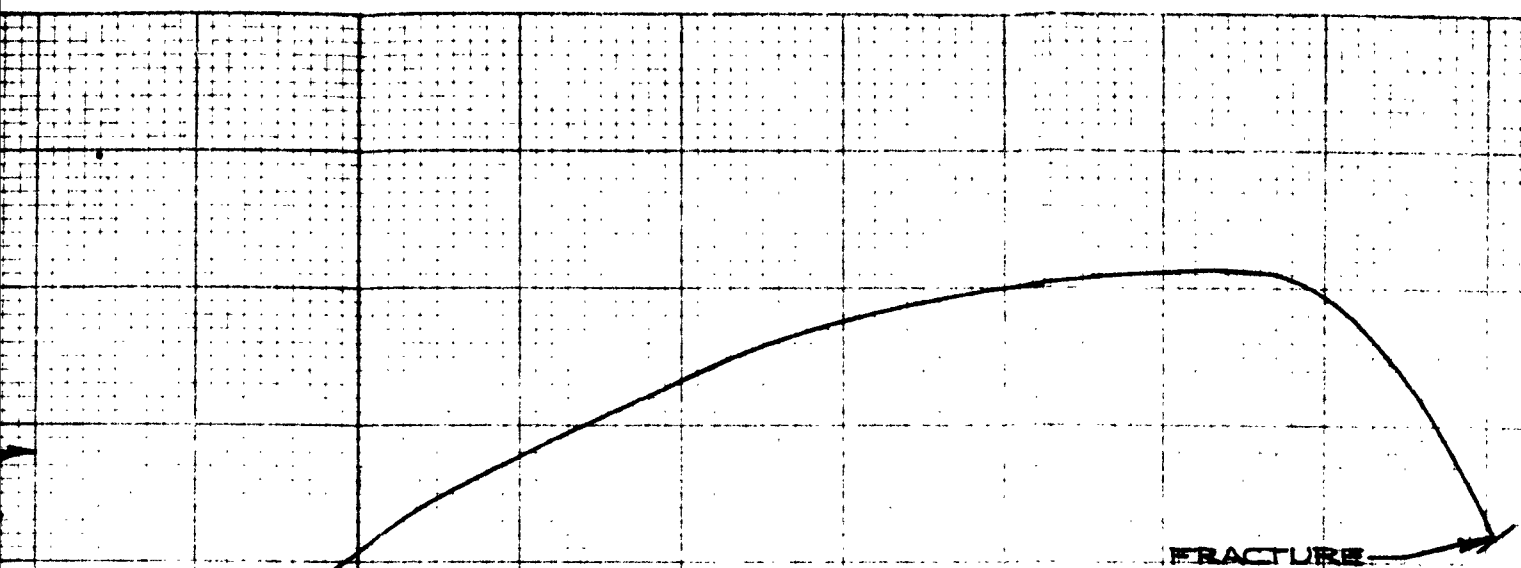
NO D2-B0080-

SEC 3



For 120 K machine only

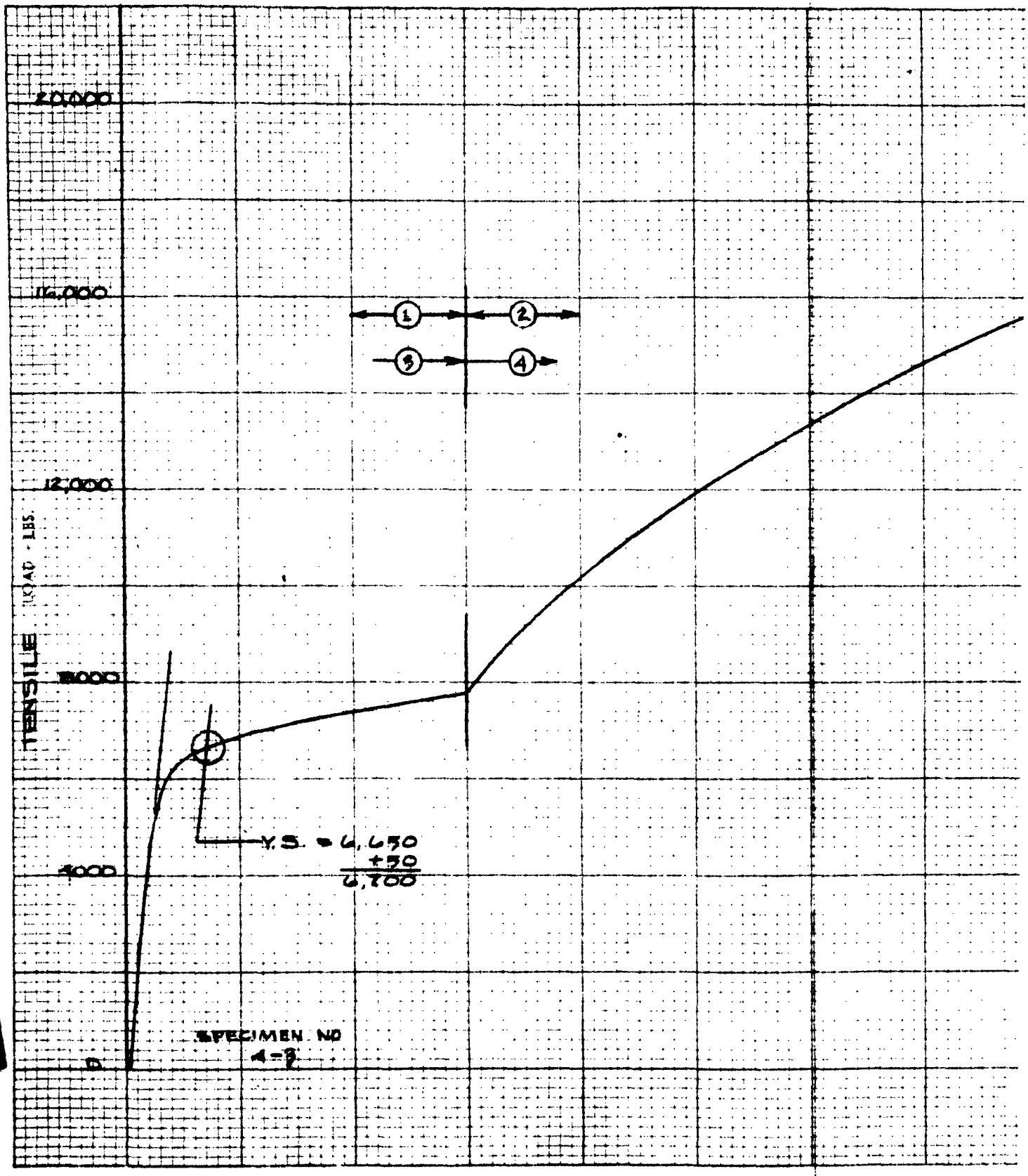
1



2

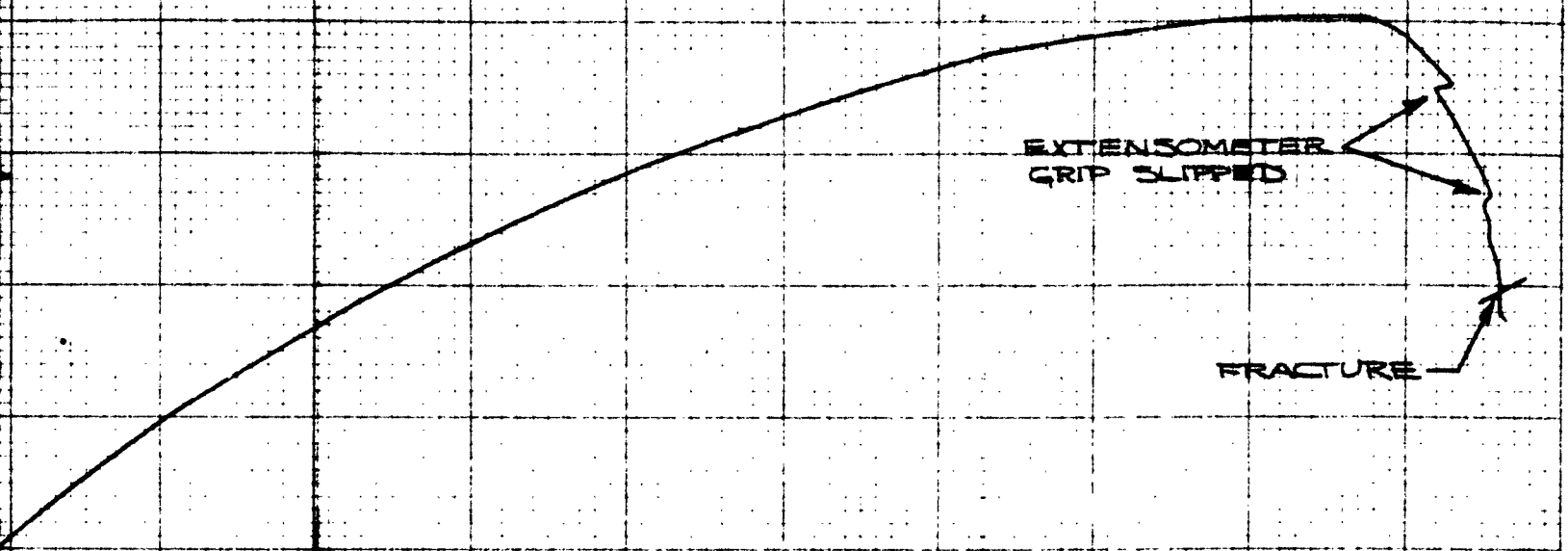
STRAIN	STRAIN RATE		
(1) .007	(2) .007		
(2) .050	(1) 0.10		

EL.S. 4130b



For 120 K machine only

1

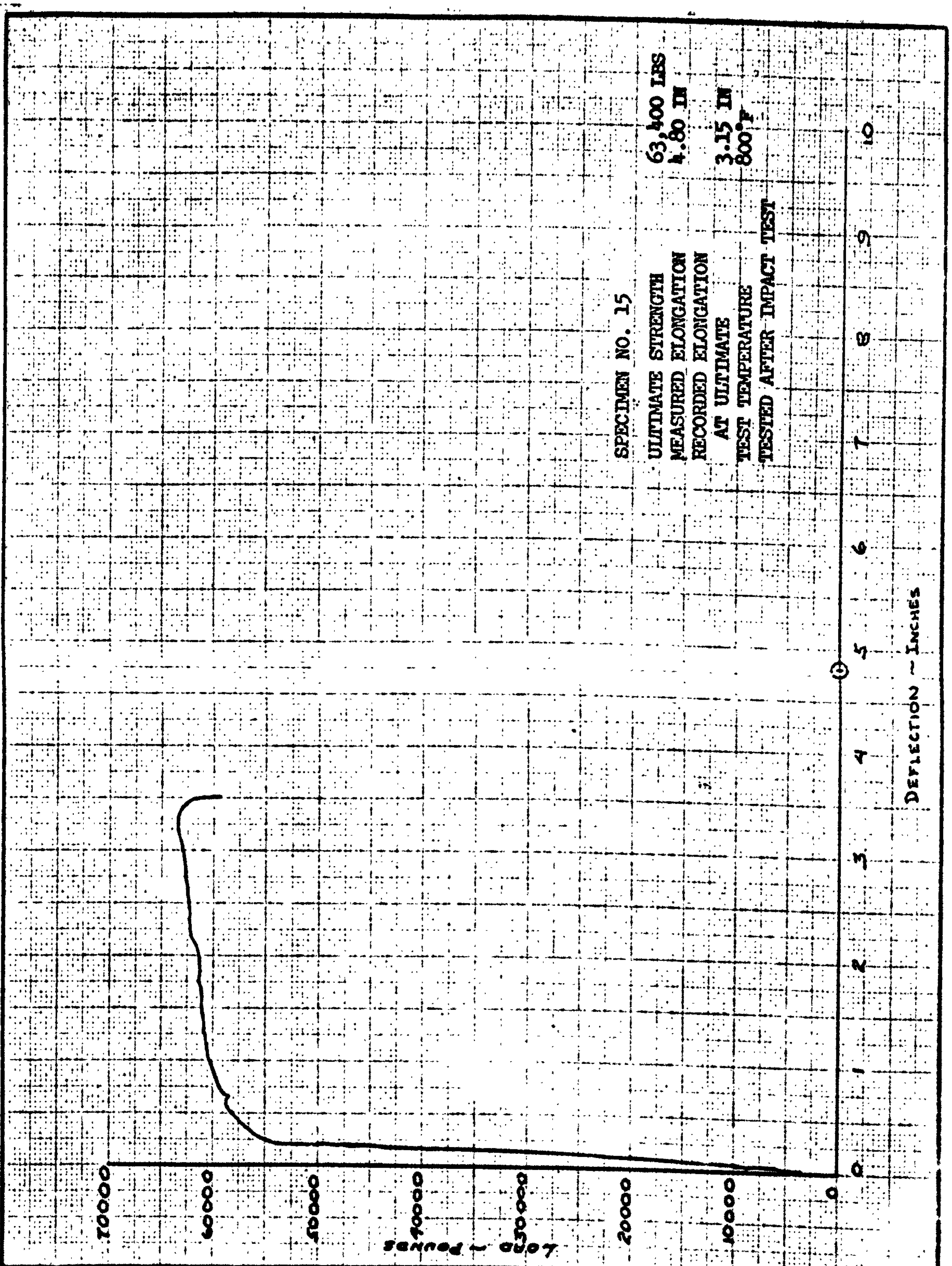


2

	STRAIN IN/IN	STRAIN RATE IN/IN/MIN	LOAD RATE #/MIN	DEFLECTION IN
①	.005	③ .005		
②	.050	④ 0.10		

CALC E.L.S. 4/20/73

CHK'D ATD



CALC	[illegible]	[illegible]	REVISED	DATE	RAPID RATE LOADING LOAD vs DEFLECTION D.S. LANDING GEAR ENERGY STRAP	X-20
CHECK	McDANIEL	7-27-62				D2-800
APR						
APR					BOEING AIRPLANE COMPANY	PAGE 3-56

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